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VOLUME XVI.

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TECHNICAL EDUCATION.

THE desire shown by the City companies generally to advance the cause of technical education, as evinced by the conference recently held at Marlborough House, leads us to hope that many of the guilds will—following the example of the Goldsmiths' Company—undertake the superintendence of a system of instruction suited to their respective crafts. The City companies, each as representing a trade, are particularly qualified for promoting technical education; but it is difficult to see the gain to be derived from their acting collectively, as suggested by some of the speakers at the Marlborough House Conference. Indeed, from the very nature of technical education, it is impossible to arrange a common code or system that will be applicable to every trade, imparting, as it should, to every apprentice and young workman those principles of design and construction involved in his particular art, which cannot be gathered by simply working at his trade day by day.

The various branches into which the horological trades and workers in the precious metals are divided, require artistic and mechanical ability, and, here in London at least, no trade is so well provided with the means for the requisite technical education. The artistic instruction is most worthily provided for by the Goldsmiths' Company, who have established a school in the centre of the district devoted to watchmakers and jewellers, where gratuitous instruction is given in designing, drawing, and modelling appropriate subjects. The rudimentary technical knowledge being thus gained, the Company annually offer prizes as an incentive to those possessing extraordinary ability to come forward, and, while making their own positions in life, securing to the nation the benefit of the talents they possess. The culminating honour and reward offered by the Goldsmiths' Company is a travelling scholarship of £100 per annum, which may be given to a student who has shown exceptional talent. The whole of the conditions of this year's prizes are printed on the cover of this *Journal*, and we most heartily commend them to our readers' attention. We believe no other City company has yet arranged so complete a scheme, or done so much for the cause of technical education, as the Goldsmiths.

The branches requiring mechanical knowledge are provided for by the Council of the British Horological Institute. Classes, in which the students are grounded in the laws of mechanics and taught mechanical drawing, are held at the Institute. Exhibitions of work will also be held at the Institute, and prizes given to the producers of those specimens showing the greatest excellence, due regard being paid to the age and experience of the exhibitor.

Reverting to the City companies, much has been done by the Turners', whose prizes, from the fact that the art of turning is not confined to one trade, fall to artificers in different branches of industry, and we gratefully remember that last year their prizes were wholly offered as a stimulus to the various branches of our own art; this year turning in stone and ivory will form the subject for competition, thus offering an opportunity which, we have no doubt, will be seized by the manufacturers of watch jewels and other workers in precious stones connected with our art, who will notice by the conditions which are published in full in our advertising space, that the prizes are not offered for strictly mechanical accuracy (except so far as turning two objects exactly alike), but especially for beauty of design and skill in overcoming difficulties in regard to the material.

The Coach-makers and Coach Harness-makers, the Stationers, the Cloth-workers, and some of the other Companies are doing work, but at present with schemes more or less fragmental. We trust, however, that ere long many companies will have complete systems of technical education in full swing, turning the talent of the English mechanic, now so often wasted upon impossible contrivances for want of mechanical knowledge, as even the records of the Patent-office will testify, into channels where it can promote the prosperity of the country, and giving us something better than the miserable abortions we so often have when artistic design is attempted.

EXHIBITION OF WORKMANSHIP AT THE INSTITUTE.

On Monday, Nov. 10, will be opened the first exhibition devoted exclusively to work connected with the various branches of the horological trades. Everything that anxious thought could suggest has been done by the Council of the Institute, and it now only remains for the workmen in every branch to send in specimens of their very best, not forgetting to send in with their exhibits the name of a gentleman whom they would like to act as judge, as pointed out in the conditions published in the June number of the *Journal*, at page 123. In response to an invitation to name one of the Judges, Lady Burdett-Coutts has requested Sir Charles Wheatstone to act in that capacity, and Sir Charles has acceded to her ladyship's request. At the solicitation of the Council Mr. Kullberg has also consented to act as one of the Judges.

Appended are the amounts of the prizes to be given for the best specimens of work in some of the chief branches. Other prizes will be given, varying in amount with the importance of the branch and the degree of excellence shown by the specimens.

A prize of £5 for the best Chronometer Escapement.

A prize of £5 for the best Lever Escapement.

A prize of £5 for the best Finishing.

A prize of £5 for the best specimen of Keyless Work.

A prize of £5 for the best made and applied Balance Spring.

A prize of £5 for the best specimen of Case-making.

In addition to any other prize which may have been awarded to him, the producer of the best specimen of work in the Exhibition will receive the Silver Medal of the British Horological Institute.

The judges will have the power of withholding the prize in any particular branch should none of the specimens be of sufficient excellence.

The work of apprentices will receive special consideration.

Any exhibit to be eligible for receiving a prize must have been produced specially for the exhibition.

The last day for receiving specimens for competition is Saturday, 1st November.

THE HIGHER HOROLOGICAL ART.*

RULES FOR THE CONSTRUCTION OF ASTRONOMICAL, NAUTICAL, AND OTHER EXACT TIME MEASURERS.

(BY URBAN JURGENSEN.)

(Continued from Page 156.)

CHAPTER III.

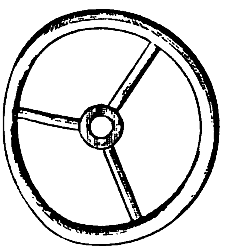
Upon the Balance and the Balance Spring. Compensation by the Curb and the Balance. Isochronism of the Oscillations by means of the Balance Spring.

SECTION I.

The Balance. The Balance Spring. Reducing the effect of outer motion upon the Balance. The resistance of friction at the Balance pivots. The resistance of the air.

THE balance is the regulator of such timepieces as have to submit to external motion, and is, as we know, a circular body, concentric with its axis, and which in every possible position is in perfect equipoise. On the ends of the axis of the balance (the balance staff) are pivots which work in suitable holes to increase to the greatest extent the freedom of the motion of the regulator.

Fig. 12.



A pendulum swings by means of gravity, a balance by means of a very elastic spiral spring called the Balance Spring. The balance and balance spring are shown in Figs. 12 and 13. A balance once set in motion would continue moving for ever were it not for the friction of the pivots and the resistance of the air, which gradually stop the oscillations. In order to sustain these it is necessary to employ a force which shall overcome the friction at the pivots and of the air upon the balance. This force must be greater or less according as the balance suffers more or less resistance from friction; but as the balance should oscillate as freely as possible, and be affected as little as may be by external motion of the timepiece, we must arrange it in such a manner that the friction and resistance of the air are reduced to the lowest amount, without of course losing sight of certain other matters essential for exact timekeeping.

Fig. 13.

External motion, or shaking, of a timepiece with a balance has an effect upon the oscillations of the balance, increasing or diminishing their extent and having an injurious influence upon the rate of the watch; it is therefore, of the greatest importance that we should attend carefully to the following rules:—

I.—THE EFFECT OF OUTER MOTION UPON THE OSCILLATIONS OF THE BALANCE MUST BE DIMINISHED AS MUCH AS POSSIBLE.

II.—FRICTION MUST BE REDUCED TO THE LOWEST DEGREE.

III.—THE RESISTANCE OF THE AIR MUST BE THE LEAST THAT WE CAN MAKE IT.

Means of diminishing the effect of external motion upon the balance.

Any motion of a watch, such as jerking or shaking it, has, as we have said, an injurious effect upon the balance, altering the extent of its arc of oscillation. There is no means by which this effect can be quite neutralised, but it can be reduced to such a low degree that it causes no appreciable alteration in the rate of the watch.

If a watch were moved in a straight line, passing through the centre of the balance, the oscillations would not be affected thereby, as the influence upon one side of the line would be destroyed by that upon the other side; but it seldom happens that a watch is moved in such a manner, but generally more or less in a circular line, which has the most hurtful effect upon the arc of oscillation. We have to pay particular attention to this fault and provide against it as much as possible.

Let us suppose a balance swinging twice in a second, that the arc of oscillation shall be 175 degrees, and that an external motion of the watch shall be in a circle in the same plane as the balance, of the extent of 25 degrees and take place in half a second; in such a case the motion of the balance would be 7 times quicker than that of the watch, and it is easy to see that the motion of the latter could not increase or diminish that of the balance more than $\frac{1}{7}$, that is to say the increased arc would be 200°, and the diminished arc 150°. If we suppose that the balance makes 4 oscillations in the second, that the arc of oscillation is 175° and that as before, the external circular motion of the watch to the extent of 25° takes place in half a second, the motion of the balance would be 14 times quicker than that of the watch.

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* *Translated from the German, for the Horological Journal*, by Mr. George Mayer.

Charles MacDouall

CHARLES MAC DOWALL.

1790–1872.

"Nor love thy life, nor hate; but what thou livest
Live well. . . . ." —*Paradise Lost*, B.XI.

[OROLOGY has lost a veteran leader! while et firm in intellect, characterized, as ever, for is kindly, genial, and communicative dis-osition, and occupied, moreover, to the last ı the pursuit of that science to whose service, om boyhood, he had dedicated himself, in ıe ninth decade of an honoured life, Charles [acDowall has gone to his rest. Beneath the ıadow of this loss we look back through the ınals of horologic science, and see in them ·w names of greater prominence than that of ıe strenuous master workman, the ever illing expositor and teacher, who has now nished his task.

Charles MacDowall, one of a family of five ıildren, was born on the sixth day of April, 790. Of the exact place of his birth, how-ver, we cannot speak with certainty. It is enerally supposed, and indeed highly robable, that this took place at Ponte-ract, or Pomfret, in Yorkshire, inasmuch s he, "Charles, son of William and Dorothy IacDowall," is recorded in the parish register s having been baptized there on the twentieth lay of June of that same year.*

Like many, who, by their own energy, and a diligent use of present opportunities, have at length won for themselves high distinction, Charles MacDowall was of humble parentage. His father, William MacDowall, first entered the town of Pontefract as a journeyman watchmaker. He has, moreover, been des-cribed as a skilful workman, and is still well remembered as having, some fifty years since, been in the habit of making periodical visits from that place into the country for the pur-pose of cleaning and repairing clocks. After working for a time in that capacity with a Mr. Berry, he started in a small business in Pontefract on his own account, but subse-quently removed with his wife (Dorothy) and young Charles to Leeds, where he again started in business—leaving behind him the remaining members of his family, two sons and two daughters. Here it was that some of the most interesting incidents in the early life of young MacDowall took place. Not-withstanding a strong predilection for his ather's occupation it is related that, owing o the ill success of one of his elder brothers n this direction, his father determined to put im to another business, and it is worthy of remark in passing that some branch of science appears to have been considered as a first essential. Accordingly, young Charles was sent to a chemist, an old quaker, residing in Leeds, to which profession it was doubtless hoped that his attention would at length have been directed. He was here set to work in a distillery, an occupation towards which he soon showed a great aversion, in fact so much so that, within a short time of his admission, we are told, he ran away from his master. Horology was hereditary in him, and no force of persuasion seems to have been of any avail in diverting him from his resolution to follow it.

One of the most interesting of all the cir-cumstances of his early life, and that which appears to have decided his career, is told in the following story:—One day, while residing in Leeds, a gentleman called respecting, and bringing with him, a *repeater* watch. His father, however, was absent on that occasion; accordingly, but not without many injunc-tions, we apprehend, on the part of the owner, young MacDowall, not yet fourteen years old, was entrusted with the care of it, with all necessary instructions, to await his father's return, and the owner departed. But here was a rare opportunity of extending know-ledge! such indeed as had probably never before presented itself. By stealth he removed to his bedroom, where he had erected a work bench and had provided himself with such tools as came within his means, or as might have been allowed him by his father for purposes of amusement, and here, unknown to even his mother, and little suspected, he pro-ceeded to acquaint himself with so rare a piece of mechanism. He was successful in taking it to pieces and cleaning it; nay, more, in restoring every part to its original position, and, having quietly returned to the shop was in the act of delivering it up, *in going order*, to its owner—who had by that time re-turned—when his father came in to learn, with much incredulity and astonishment, the truth of what had happened. Although for the time it was an occasion of much remonstrance, it nevertheless became the turning point in Charles MacDowall's history, for from that time his father became also his tutor, and thus commenced a career such as, in its entirety, is seldom met with—a career in the pursu-ance of which came its own reward, and such as should in due time bring forth much fruit.

* Recorded in the parish church of St. Giles, arket-place, Pontefract.

On the death of his father he carried on business for his mother, but afterwards removed to Wakefield, where, in the district of Saint John's, he started for the first time in his own business. Nor did he long remain a stranger, for within a short time of his arrival there daily came to his window crowds of eager and delighted sightseers to witness the curious movements of his timekeepers. These often went their way persuaded in themselves and declaring to others that clocks were driven by steam. So great was the excitement that prevailed for these matters among the townspeople, who regarded them as by no means least of the attractions of "Merry Wakefield"* that Mr. MacDowall was compelled, either from the interference of municipal authority or for his own peace, to withdraw the most important of them. Notably amongst the attractions of his window, we believe was, his "endless gravitating and revolving gravitating timepiece," with "quiescent armillary escape," which has been described as "without springs, chains, barrels, fusees, or keys," but which, from its apparent non-existence at the present time, we are unable to describe. Here it was that he appears to have invented his "helix lever" (oblique toothed gearing), or, as he has sometimes styled it, his "circular helix," or "rolling helix lever," the valuable and distinguishing properties of which he has thus described:—"First, it passes equal spaces in equal times, and consequently is at all times at equal distances from the centre of motion,—Secondly, it has a continued line of centres, and a single point of contact,—Thirdly, its pressure is always in a line parallel to its axis, by which all friction of the shoulders is avoided,—And, lastly, it has a rolling action, which materially reduces the friction at the points of contact."

This shortly attracted the notice of *savans*, among whom was the celebrated Dr. Birkbeck, Physician, Philanthropist, Professor of Philosophy in the Andersonian Institute, Glasgow, and President of the London Mechanics Institute, at whose instance he (Mr. Mac Dowall) came to London, in or prior to the year 1836, and first resided, we believe, in Church-street, Kensington.

Writing to him on this subject in October, 1836, Dr. Birkbeck says:—"It affords me great pleasure to state to you my very favourable opinion, both of the principle and action of your helix lever clocks. Two of them I have now tried for several years, and they have moved with so much precision, although unprovided with any compensation, as nearly to approach the accuracy of a good chronometer and regulator with which I have compared them. Indeed, the larger clock, notwithstanding the inconvenience of having for its maintaining power a spring wound up only once a month, has delighted me by its great precision, and it certainly far exceeds any clock which I have seen of the ordinary construction; indeed, this might be expected by anyone who will carefully attend to the mode in which motion is transmitted, the unvarying equality of pressure, and the continued preservation of a straight line, of the important line of centres. I have little doubt that this mode of gearing, if well executed, would be found the most advantageous for large machines; for small ones, such as clocks, the superiority cannot be questioned. The action of the wheel and pinion, with all the mechanical refinement that has, as yet, been expended upon the tooth of the one and the leaves of the other is still most variable and irregular.

"It has been my intention for some time past to call upon you at Kensington; professional and other unavoidable engagements have hitherto prevented me, but I hope ere long to have the pleasure of inspecting your ingenious movements in your own workshop." *

A clock of this description, bearing the name "Chas. McDowall, St. John's, Wakefield, No. —," is in the possession of the writer's father, and has long been going to a rate equally close with the instance just mentioned. Although constructed some forty years since it apparently shows no signs of deterioration: proving, beyond all doubt, the truth of the inventor's argument.

Mr. MacDowall should here be mentioned as also the inventor of the "Helix Lever Watch," and "Helix Lever Escape," which has been styled the "ne plus ultra of Horology."

Foremost, perhaps, amongst those who interested themselves in Mr. MacDowall and his productions was H.R.H. the late Duke of Sussex (brother of George IV.), who has been described as "a patron of the horological art." Mr. MacDowall, we are told, enjoyed the entire confidence and esteem of the Duke, and always attended his *conversaziones* by special request; his special employment being to explain inventions and improvements, and to enter into discussion with the *savans* there assembled.

An interesting story is told how that on the occasion of one of Mr. MacDowall's visits to Kensington Palace, on an interview with the Duke, Princess Victoria (Her Majesty) was playing in the room when her uncle

* Formerly so called.

* Copied from the original letter *verbatim et literatim.*

(the Duke) called her by a familiar name to come and see some curious piece of mechanism which Mr. MacDowall was exhibiting. She accordingly ran up and, in childlike innocence, expressed her admiration, but speedily returned to her more congenial amusements.

In the year 1839, Mr. MacDowall resided in St. James's-street, Pall Mall; from thence he removed to Victoria-road, Pimlico, where he remained some three or four years at least, possibly longer, for here for a time we lose sight of him.

On the 15th day of August, 1847, he married, at the church of St. Clement Danes, Strand, Mary, eldest daughter of the late Richard Wilson, Esq., of Birchington, Isle of Thanet, Kent, who survives him, without issue.

In the year 1848 we find him in Hyde-street, Bloomsbury. Here, in 1851, he patented his "single-pin escapement," which was exhibited in the great International Exhibition of that year, and for which the council medal was at first awarded him, although, by reason of some alteration in the decision of the jurors, he finally received the bronze medal. This escapement is intended as a substitute for Graham's "dead-beat" and also for the common "recoil" escapement. In the place of a scapewheel, usually employed, it has a small disc, with a single ruby pin set in it, very near the arbor; the disc makes half a revolution at every beat of the pendulum, and the pallets are formed in a flat steel arm, which may be the crutch of the pendulum, or they may be arranged in the pendulum rod itself. The impulse is given chiefly by direct action across the line of centres: the action being thereby smooth and easy. The whole escapement, moreover, has the advantage of being easily made. Mr. MacDowall's priority in the matter of this invention has been questioned on more than one occasion, but we may confidently assert that no attempt of the kind ever yet appears to have equalled it either in England or France, both of which countries are mentioned as having before possessed it in some form or other, differing, however, in this respect, that a roller is said to have been used, instead of a fixed pin, which occasioned shake and much uncertainty, besides which the pendulum had a much larger arc of vibration. Be this as it may, it is satisfactory to know that the French attribute the invention to him,* while the jurors of our own International Exhibition in their decision agreed, that it combined in a high degree the several qualities which they were directed to regard in their distribution of prizes, viz., simplicity, cheapness, and, at least, probable accuracy of performance. This escapement has been very successfully applied to pocket watches, one of which came under the writer's notice some time since as having been purchased in Paris, and afterwards, by chance, shown to Mr. MacDowall, in London, who somewhat astonished the owner by telling him that it was his own invention. During its repair he caused his name to be engraved upon it as "inventor and patentee." The patent was purchased by Mr. E. J. Dent, who, notwithstanding its simplicity, and the knowledge he must have had of its performance, appears to have made but little use of it, probably for the reason assigned to the writer by Mr. MacDowall, who once stated that, on questioning Mr. Dent as to why he did not use it, he (Mr. Dent), pointing to a case of watches, replied, "What am I to do with these?"

* "Encyclopédie Roret." "Horloger," p. 188. *Echappement-épingle de M. MacDonald,*"—evidently "MacDowall."

There is reason for believing that to Charles MacDowall falls some of the credit attaching to the invention of the "three-legged gravity escapement," although by no means the whole of it. Nor did he claim it. It would appear that his share lay in the arrangement of the 'legs' which were somewhat curiously styled by him, the "Isle of Man." A life size portrait in oils, in the possession of his widow, represents him as standing by a table upon which, at his left side, is seen a small four dial clock, the pallet lever and balance staff of his single pin escapement, and that portion of the "gravity escapement" already mentioned.

Among other matters Charles MacDowall claimed, as one of his productions, that very useful instrument, the "spiral drill." His claim, however, in this direction, has been rightly disputed. We are, nevertheless, right in assuming that, so far as *his* knowledge was concerned, the matter was original. The drill, moreover, as produced by him was the first, of which we have any knowledge, in metal having been made of twisted pinion wire, in the place of wood which had been previously used, and was a result of certain considerations on his "gravitating time piece" *which preceeded it*; affording us, thereby, an unquestionable right in this belief. He had, doubtless, like many another, trodden on what to *him* was new ground inasmuch as, by the direction he had taken, he discerned not the footprints of another,—

If there is nothing new—but that which is
Hath been before—how are our brains beguil'd,
Which, lab'ring for invention, bear amiss
The second burthen of a former child.

But, although, *in this instance*, we are compelled to speak of Charles MacDowall only as a re-inventor, there are matters yet to be considered, in relation to the subject, which have brought to him scarcely less honour than that attaching to his predecessor. The spiral drill in his hands became an instrument adapted to even greater use than that of piercing metals. By placing a rose drill on the extremity of, and at right angles to the thread, he adapted it to purposes of dentistry. He further suggested its use in an important matter in surgery. He also designed an instrument for the removal of bone from a fractured skull, such, however, as, in the opinion of the late Sir Benjamin Brodie, Bart., could only be entrusted in the hands of a most careful practitioner. Of the time, and place, in which he carried out these ideas we have no information.

It is beyond our present purpose to give anything like a detailed description of those labors which have brought such lasting honor to, more especially the science of horology. We shall prefer to treat of such of them as may be authentically described on a future occasion, directing our attention for the present to the author of them.

In the year 1858, at the advanced age of sixty-eight years, we first trace our departed *confrere* as residing in Jermyn Street, St. James's, where he spent the remaining years of his life. Here, with eye undimmed and natural force unabated, he continued faithful to the last in his loyalty to the truth. Although in comfortable circumstances his happiness rarely, if indeed ever, consisted in them. He had sometimes been questioned as to why he did not give up and spend the remainder of his life in rest and retirement, to which he replied:—"I cannot leave the bench," or, "I'll think about it." He had no part or lot in that order of men who live and act as though the accumulation of wealth were the end and object of existence. Rather did he appear to follow that voice which said to him "Wisdom is the principal thing; *therefore* get wisdom: and with all thy getting get understanding. For the merchandize of it is better than the merchandize of silver, and the gain thereof than fine gold."

But, much as we have said of him, Charles MacDowall was not without some of those littlenesses which go to make up the sum of human imperfection, but even these were so transparent and childlike, when contrasted with the goodness of his heart, that we well nigh loose sight of them in our estimation of him. One circumstance occurs to us worth mention, if only to show the reality of his character. It happened some time since that a watchmaker had experienced some difficulty in the construction, or going, of a clock in which he had adopted the "gravity escapement," whereupon he called upon Mr. MacDowall soliciting his assistance, and the benefit of his experience, in the matter. Mr. MacDowall had, however, by some means been upset and answered his applicant somewhat sharply, telling him that he (the applicant) might as well put his hands in his (Mr. MacDowall's) pocket and take his money as to come to him under such circumstances, and requested him to leave the shop, upon which the applicant, with a "good morning," turned to do so. But there was something in the character of Charles MacDowall which did not permit this. Calling him back he said to him in a more kindly tone, "There, what is it you do want?" nor did he allow him to depart until he was persuaded that he had made him master of his difficulty.

Charles MacDowall was a close, indeed a reverent observer of nature. Irreverence, in others, whether in matters of nature or revelation, displeased him. "The starry heavens and the sense of moral responsibility in man"* were alike to him subjects for wonderment and awe.

Of the depth of his religion it does not, perhaps, become us here to speak; we would rather describe him as one who did not talk, but *lived* christianity. Whether in conversation about his inventions, which were described with an intensity of interest such must often have excited wonderment on the part of his hearers, or on the affairs of every day life, it was impossible not to feel his influence, and, to use the language of a modern writer, "all that was best in one's nature rising to the surface." Although he had long since passed the allotted span of man's existence, he had, up to within a short time of his death, enjoyed an almost uninterrupted health. During the latter part of the year 1871 he was suffering, says his medical adviser, from *Angina Pectoris*, from which he apparently recovered. It was not until the night of Saturday, the twenty-sixth day of October, of last year, and not yet twelve months since, that he was finally taken ill. He had put away his watches, as was his custom, and was sitting by himself in his half closed shop reading the days' news when he suddenly fell from his stool insensible. He was removed to an adjoining room, medical assistance was immediately procured, but at an early hour on the following (Sunday) morning, October 27th, ere yet the "day of rest"

* "Two things," said Immanuel Kant, "fill me with awe: the starry heavens, and the sense of moral responsibility in man."

had scarcely dawned, his spirit passed beyond our earthly horizon. On the following Saturday his remains were deposited in their last resting-place in the little village churchyard of Birchington, Kent.

Some idea of his real worth and the estimation in which he was held by those who best know him may be gathered from the following letter, addressed to his widow a few days after his death, by one who had long enjoyed the privilege of his acquaintance:—

14, Blomfield Terrace, W.,
1 November, '72.

DEAR MRS. MACDOWALL,

It was not until last evening that I learnt of the death of my dear old friend, so I hasten to assure you of the sympathy I feel for you in having to bear such great sorrow and trouble. I feel that I have lost one of my oldest and best friends, and it makes me sad indeed when I think I shall see his face no more. Once more let me assure you of the sorrow I feel at your terrible bereavement, and believe me to be

Yours faithfully,
GEORGE BRODIE.

But although he has left scenes once brightened by his ever-welcome presence, he still *lives* in the hearts and memories of all who knew him; lives by the example he has left us; lives in the truths which he has taught us. Whether, like young Herschel and his little band of college companions, he started in life with the noble vow and resolution that "he would leave the world better than he found it," we know not: this we *do* know, he has undoubtedly accomplished it.

"The evil which men do," says our great dramatist, "lives after them, *the good is oft interred with their bones.*" May it be otherwise in the life we have now considered. May the example that Charles MacDowall has left us become amongst us a living influence, arousing in many a student and worker in science a spirit of noble enthusiasm, not least amongst those who follow that science to which his life was specially consecrated.

Truly,—

Lives of great men all remind us
We can make our lives sublime,
And, departing, leave behind us
Footprints on the sands of time;—

Footprints, that perhaps another,
Sailing o'er life's solemn main,
A forlorn and shipwrecked brother
Seeing, shall take heart again.

Let us, then, be up and doing,
With a heart for any fate;
Still achieving, still pursuing,
Learn to labour and to wait.

JOHN JAMES HALL.

METHOD OF FROSTING STEEL KEYLESS WORK.

As there are very few watchmakers in England who can produce the fine frosted surface to steelwork such as is found in Geneva keyless wheels, and as I know many good workmen who have lost much time over it and yet failed to get a satisfactory surface; I think a few remarks on the process will be welcomed by the readers of the *Horological Journal.*

Finish the surface to be frosted perfectly free from scratches. On a piece of perfectly clean plate glass with a ground surface, crush a bit of clean Levant oilstone to a fine powder and mix with a little clean sweet oil to a thickish paste. Now comes the part of the operation, the omission of which is often the cause of failure. With a strong magnifying glass very carefully search for and remove all black atoms from the oilstone dust, for if any of these atoms are left they will inevitably scratch the work. Now, with a steady heavy pressure upon the work move it on the glass slab, not describing circles, but with as short a backward and forward motion as it is possible to give, continually shifting the peg or other tool with which you hold it and keeping a fair supply of the oilstone dust between the work and the glass. When sufficiently rubbed, well wash the work in hot water and clean with soap and a soft brush, rinse it in spirits of wine, wipe it with a clean rag and rub with rotten, or, as sometimes called, touchwood. To finish the work it must be further rubbed in a circular direction with pith.

A little practice will, if the foregoing directions are adhered to, ensure success.

If, after completing the operation, the desired surface is not attained, the whole must be repeated; but from beginning to end care must be taken to have everything perfectly clean.

W. G. SCHOOF.

THERE was received at Melbourne in the year 1871 jewellery valued at £22,496, of which £9,950 had to pay an import of 12½ per cent., and £12,546 of 20 per cent.

VIENNA EXHIBITION.—The *Diploma of Honour of the Universal Exhibition of* 1873 *in Vienna* has been awarded to Mr. V. Kullberg for his exhibits in Class XIV. Mr. Kullberg is the only recipient of this prize in Class XIV., which includes mathematical and astronomical instruments, horological instruments, and surgical instruments. It is very satisfactory that this particular distinction, which is awarded by the President's Council on the recommendation of one of the Group Juries, has been secured to a representative of English horology.

REMINISCENCES OF THE VIENNA EXHIBITION.

(From an Esteemed Correspondent.)

The prevailing feature of the horological department is certainly the number of Vienna and German domestic clocks. The Exhibition literally swarms with them, some with seconds mercurial pendulums and most elaborate cases, the cases of some costing as much as a good English regulator.

Ornamentation seems to be carried almost too far; it would be preferable if the amount of work lavished on ornamentation had been employed to make them exquisite timekeepers. The North Germans show a couple of fine regulators, which for workmanship can compete with anything that is made. In the exhibition grounds a small house is exclusively devoted to the progressive history of Black Forest clockmaking, beginning with the very earliest clocks having a verge escapement, a horozontal balance or rather a bar with weights suspended at the ends evidently for correcting long and short vibrations, and ending with the modern styles now prevailing, having the appearance of Vienna and French clocks.

The French also show plenty of clocks which, all being ornamental, have no pretensions to timekeeping qualities. A clock having a free pendulum swinging over the movement and apparently free of it is exhibited. The pendulum is held by a figure standing on the case. The base supporting the figure stands freely on a pivot and is made to rock to and fro imperceptibly by a series of levers, which also serve as an escapement. Apart from its ingenuity, it has nothing to recommend it, and must be considered a mere toy.

The French section of the horological department was not in a very complete state when I visited the Exhibition; one of the horological schools was just unpacking, and Breguet and one or two other noted French manufacturers had not then put in an appearance.

In watches the Swiss are particularly strong, being one of the chief industries of that isolated little republic. The workmanship of their fine watches is bordering on perfection, and the Swiss are certainly using every means in their power to extend their market to all parts of the world; and so far have they arrived that if the English watchmakers do not soon combine it may be too late to interfere. It is curious, however, to see how they adopt everything connected with timekeeping from the English. Not long ago it was the fashion amongst Swiss watchmakers to have very long levers, so that the pallet-arbors could free the balance. This is now quite reversed. Their levers are now made even shorter than the English and much lighter to boot.

Formerly their balance springs were bent in a way peculiarly their own; now they bend their springs also like the English, but, in order to make them appear modern and to be superior to their old formidable rivals, they call them "Phillips' springs."

One mistake, however, the Swiss make, and that is that for their fine watches they do not use the fusee; it is saving a few shillings at the foundation, in order to be compelled, so to say, to waste pounds at the finish. But I suppose it is in order to show some difference to the English, and they have thereby more room to display their ingenuity in the arrangement of their cocks and bars, which seems a most important part of Swiss watchmaking. Let it not for a moment be understood that the writer of this is oblivious of the advantage of work which pleases the eye and induces customers to buy; but beauty may be carried too far, reminding one of the tale about the man who carved his bow so much as to cause it to break in the setting up. For cheap ordinary watches, however, the going barrel is quite good enough, and, being often in the jobber's hands, are much preferred by some watchmakers. There is one important point in which the Swiss have the advantage of the English, and even that is of English origin. They have observatories in Geneva and Neufchatel where the watches of a superior kind are tried somewhat similar to the way the chronometers are tried at Greenwich, only their trials last as many weeks as the English trial lasts months, and through this competition between the two observatories (Geneva and Neufchatel) they have managed to get marvellous rates, the one observatory always (as I am informed) striving to show finer rates than the other, though the town that contains the best makers seems to turn out the less perfect rates. The Swiss study at their observatories to make the rates look as fine as possible, whilst at Greenwich the rates are shown without any polish, simply plain facts. This gives the Greenwich rates an advantage over all other rates; they show the truth and nothing but the truth. No fair comparison of the going of the best English fusee work and the finest watches of Swiss manufacture can be made except through some arrangement between the Swiss and the English to have their watches tried at the same time and under precisely the same circumstances.

Some such arrangement would, I believe, be productive of much good, and I trust that

the Journal and Institute will be the means of making the English and Swiss manufacturers alive on this point. Let them set the example and show that watchmakers can be real "Internationalists," working together for the progress of our art.

The English exhibitors show principally chronometers, and are, undoubtedly, without rivals in that branch. Watches are also shewn, certainly as fine as any country can produce, but in numbers not nearly so numerous as the Swiss. Chronometers are exhibited by French, German, Danish, Dutch, and Russian makers, the Russian chronometers being kept going by electricity. No turret clocks or regulators are exhibited by England.

I was rather struck with the fact that, although so many large watch factories flourish in America, there were no exhibitors of watches from that great country.

The Americans have some of their well-known cheap clocks. The Germans also show clocks on the same principle as the Americans, and it requires some study to see the difference. With most German exhibitors of turret clocks an escapement is used for giving the impulse once every minute, some with force constant and some not. The Dutch seem to have the finest turret clock in the Exhibition, although not the largest.

ON THE PROPER SHAPE OF THE FUSEE.

THE question having arisen a few weeks back as to the proper shape of a Fusee, I was led to look into the matter.

All the books I consulted on the subject stated that as the strength of a spring increases or decreases uniformly as it is wound or unwound the correct form of a fusee is an hyperbola; but this in practice appears to be untrue, which I will endeavour to show.

For this purpose, let us assume a barrel, as in Fig. 1, which is to take say four coils of gut and that one turn of the spring is necessary to be taken for set up to give a preliminary tension to the spring. This set up is indicated by dotted lines to the extreme left.

Admitting that the force of a spring varies as the tension, we will suppose that one turn of the spring gives a strain of say 2 lbs. on the gut; two turns will give 4 lbs.; thus at the commencement of the gut coil there will be 2 lbs. strain, and at the end of the first gut coil there will be 4 lbs. strain, and so on, as shown, till at the end of the fourth coil of gut and of the fifth turn of the spring there will be 10 lbs. strain.

Now, let us suppose that a fusee with a radius of 12 at the large end is to be used, as in Fig. 2, it is manifest that 12 × 2 lbs. = 24 will be the strain in units of the fusee at starting to wind up the spring; it is evident, therefore, that at the end of the first or beginning of the second gut coil that 6 must be the rad. of the fusee, for 6 × 4 = 24, and so on till the last coil, which must be 2·4 rad. for 2·4 × 10 lbs. gives 24 as at starting.

FIG. 1.

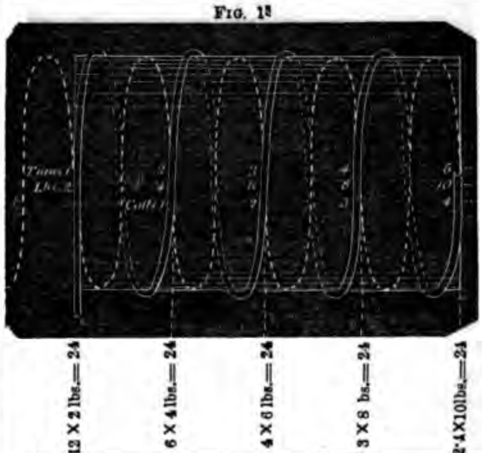


FIG. 2.

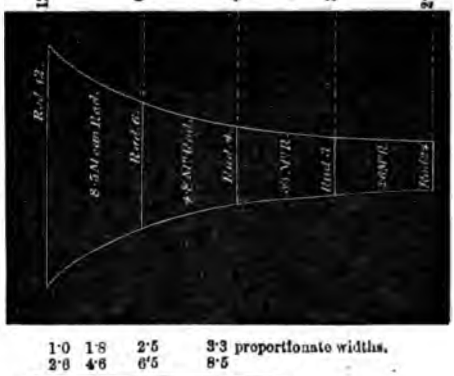
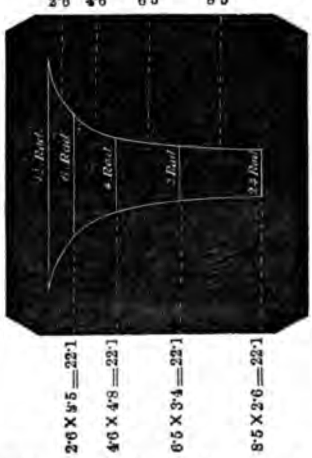
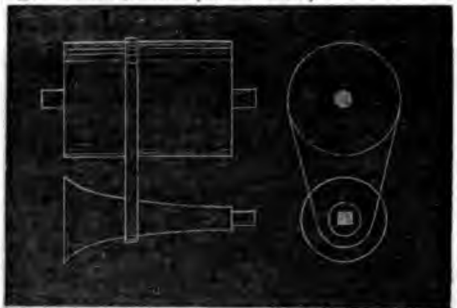


FIG. 3.



This curve, shown in Fig. 2, is an hyperbola, and is generally given as the correct

form of a fusee. This would be true if the connection between the barrel and fusee were made by an endless band or gut which passed half round the barrel and half round the fusee, this band being shifted endways as the power of the spring required that the force should be made to act at a shorter or longer radius, thus (see sketch):—



But as, in practice, a line is used which coils on to, or uncoils from the barrel, from or on to the fusee, this hyperbola shown in Fig. 2, must be modified, because it is evident, although the curve obtained gives the right leverages to get a constant relative strain on the arbor, the spaces being equal and the radii varying, that a spiral cut upon this curve as a pitch line would take different quantities of line from the barrel, so these lateral distances must be varied inversely with the mean radii of their respective spaces, as in Fig. 3, where it will be seen that any rad. multiplied by its width will be equal to any other rad. multipled by its width, so that from rad. to rad. would contain equal quantities of gut.

It appears, to reduce this to practice (suppose it were wished to dispense with the adjusting rod), it would be necessary to decide how many turns of the spring were to be used before the barrel came into play (*i.e.* set up), next to decide how many turns of barrel and spring were to be used, then to set out from these data curves, as in Figs. 2 and 3, then decide the mean diameter the fusee is to be, and settling what distance the coils of gut should be apart, would give the length of the curve, which must be constructed proportional to the one shown by Fig. 3.

The length of gut obtained by multiplying the circumference of the barrel by the number of coils, and divided by the mean diameter of the fusee curve, would give the number of coils on the curve, which, multiplied by the width apart of the grooves, would give the length of the fusee.

It must be borne in mind that if a weaker spring be used than the imaginary sne taken, say one that requires $1\frac{1}{2}$ turns instead of one turn to give the desired set up, then there will be required three turns of the spring instead of two to double the strain on the fusee, and, therefore, the rad., which is represented in Fig. 3 by rad. 6, will be placed further to the right, as the fusee, instead of receiving one coil of gut from the barrel between rad. 12 and rad. 6, will have to receive $1\frac{1}{2}$ coils, and similarly between rad. 6 and rad. 4 $1\frac{1}{2}$ coils would have to be got on the fusee, which places rad. 4 further to the right again; in fact, the set up of the spring forms the base of the calculation, so that although the curve of a fusee, if a band were used, would still be an hyperbola, yet the fusee in practice would be flatter than the one shown in Fig. 2.

But the foregoing is based on the assumption seldom or never occurring in practice, *i.e.*, that all the coils of the spring are free to exert their force from the commencement to the end of its motion thus; but suppose, as is frequently the case with a spring having say nine coils, that when the initial tension is given five coils are free and the remaining four coils are close against the inside of the barrel thus.

When the spring is being wound up we have first one of five coils to deal with, then one of six, seven, eight, and, lastly, nine coils, so that instead of the 2, 4, 6, 8, 10 lbs. strain on the gut, as shown by Fig. 1, we should probably get something like $2\times1 = 2$ lbs. strain to deal

$$\left.\begin{array}{l} 2\times2\times\frac{5}{6}=3\frac{1}{3}\text{ lbs.} \\ 2\times3\times\frac{5}{7}=4\frac{2}{7}\text{ lbs.} \\ 2\times4\times\frac{5}{8}=5\text{ lbs.} \\ 2\times5\times\frac{5}{9}=5\frac{5}{9}\text{ lbs.} \end{array}\right\}$$

with to form Fig. 2; this would again require to be modified as before into Fig. 3.

From what has been said it appears that a fusee once cut to suit a particular spring is unsuited for springs of different strengths, although it is possible by shortening, lengthening, or setting up the springs to reduce the error to a minimum.

E. PERRETT.

Production of Gold in Finland.—During last autumn there were no less than seventeen companies engaged in extracting gold from the auriferous sand of Finland. The alluvial deposits at Toalo are said to be extremely rich in gold, the total production last season being estimated at from 50,000 to 60,000 grammes, representing a total value of 60,000 roubles (9,500).

TRIAL OF THE "PYX."

On Thursday, July 17th, in the Goldsmiths' Hall, there was held what is called a "trial of the Pyx." It simply means an examination and an "assay" of the moneys which have been coined in the past year at the Mint from samples taken hap-hazard from the different specimens thrown into the Pyx, or box. The custom of thus testing coins arose, it is said, as far back as the reign of Henry II., when, failing other resources, it was not an infrequent habit to so debase the coinage as to issue £50,000 in silver marks so intermingled with tin and other alloys as only to represent about half the nominal value in metal.

Each day's work at the Mint is called a "journey," a mere corruption of the Norman term for a day's labour. From each "journey," whether of silver or gold, a certain number of coins are put into an envelope, sealed with the seals of three different officials, and deposited in the Pyx for the day, which is again sealed with three seals, and all kept in the vaults till the trial of the Pyx commences. This trial used until the last two or three years to be made at Westminster, and only about once in five or seven years. Now it has been made annual, and the trial is held at the Goldsmiths' Hall, as being more convenient for the purpose. The wardens of the Goldsmiths' Company superintend the operation of the assay, and a regularly constituted jury of twelve gentlemen are sworn in to give their verdict. The jury are entirely composed of craftsmen of the guild of goldsmiths, bullion dealers, silversmiths, &c., gentlemen who are accustomed every day to test and value the assay of precious metals, both by weight and purity, by acid, and by fire. In the last year there were coined by "the Right Hon. Robert Lowe, Master and Worker of her Majesty's Mint," 5,809,680 ounces of silver coins. The smallest coinage was of 1,440 ounces on December the 18th of last year—the largest, 72,000 ounces, on January the 16th of this year. The total value of the silver coinage was £1,597,662. Of the samples of this mintage sent into the numbered pyxes in each day's working there were 4,481 florins, 2,739 shillings, 650 sixpences, two fourpenny pieces, 200 threepenny pieces, two twopenny pieces, six penny pieces—in all to the value of £603 17s. 6d. Collectors of coins will observe that the number of fourpenny pieces now struck is almost *nil*. In fact, it is not the intention of the Mint to issue any more of them. It is the same with half-crowns, not one of which has been struck during the past year; and it has been the same with five-shilling pieces during the last two years. As a matter of fact, only about 4,000 of these crown pieces are struck each year, and they go entirely to the Falkland Islands, where the whalers in the South Seas winter, and where this is the only coin which passes current, just as only the Maria Theresa dollars will be accepted in the Persian Gulf or along the shores of the Red Sea. The Pyx of the gold coinage represented specimens in all amounting to £14,313. This was taken by chance from an aggregate coinage of 2,900,000ozs.—for it is needless to give the mere decimals. It represented a total value in coinage of nearly eleven millions and a half sterling. The largest amount coined during the past year was 72,000ozs. of gold on the 27th July: the smallest on the 26th of last June, when only 5,221ozs. were struck. The number of half-sovereigns issued from the Mint is not more than 25 per cent. of the coinage—in fact, the Mint seems to discourage as much as possible the issue of anything but their own favourite coins—the florin, the shilling, and the sixpence, It is a popular fallacy to suppose that the Mint is bound to coin for any one. By law it is not bound to coin silver at all. Gold it must take, and issue to the depositor the gold he lodges with them, in its weight in sovereigns. This custom, however, has sunk into disuetude, for the Mint buys its bullion according to its price in the market, where it varies like any other commercial commodity—as coals or corn. The last depositor—or, we might say, intending depositor—was the late Mr. Peabody, who sent £200,000 in ingots to the Mint, wishing them to be returned in sovereigns. It was, however, explained to him that he would make a much better bargain with the bullion dealers when the price of gold rose; and to this advice he listened, and prudently took his ingots away.

Thursday, in the inner court of the Goldsmiths' Hall, there was the usual jury sworn, as we have already mentioned, and the work went on as quietly as it does in the ordinary inner parlour of a bank. There were a certain number of the jurymen who counted the coins by tale, who verified on a certificate the contents and dates of each packet taken from the pyx, as the seal was broken and its contents numbered. It was a very silent and a very dreary operation to see them counting out, hour after hour, mere envelopes of silver or gold as the case might be, and sending them out into the next room, which was only divided from their own by a glass screen, to be weighed in the carefully-adjusted scales, which will turn at such a decimal of a grain as we almost fear to mention in case of a mistake. It was curious to see the weighing-room, where everything was carried on with a silence

that might have become a funeral. In no case was the gold found deficient in its standard weight—nor was the silver. The bullion, however, had to go through more processes than mere counting and weighing. From each package of gold a certain number of sovereigns was selected, mingled together, melted, and then assayed. But the result was always the same. With some infinitesimal deviations, they came out pretty much all alike, and all far within the limit of the "Master's remedy." In fact, except by chemical analysis, nothing could be detected but standard gold. The silver was more severely tried. It was weighed, melted, and tested with acids till the result, on the whole, showed that, if anything, it was rather above than below the standard which the Mint requires. The test with acids, nitric and muriatic, is with silver far more searching than any which is applied to gold, for the simple reason that an excess of alloy can be at once discovered in gold, whereas it is not so easily discernible in the less valuable metal. At the end of the day's labours, when all the money had passed through inspection by tale, by weight, by fire, and by test, the output of the Mint was pronounced perfect by the jury, and in the evening, after their labours, they dined very amicably and even sumptuously together at the Goldsmiths' Hall.—From *The Standard.*

Letters to the Editor.

All letters to be addressed to the Editor, at the Institute, 35, Northampton Square, E.C.

Sir,—If your correspondent who signs himself "Clerkenwell," (page 157, August, 1873) refers, as I presume, to a going barrel watch, I quite agree with him, and have often thought the same thing quite possible myself; but I think if the ratchet teeth are a little undercut, or the ratchet itself (if not made in one piece with the arbor) is just a little loose on the square, the fault could not occur, except while the arbor is held wound tight up by the person winding it, that is as much as to say, unless it is done purposely. You cannot wind a watch up quite tight, if it is made as I suggest, for if the point of click drops in the wheel exactly when the watch is tight up, if the teeth are undercut it will run back a little when the winding power is removed; and if the ratchet is a little loose on the square, the same thing will occur of necessity, so that in this case a slight imperfection in the workmanship may be an advantage rather than a defect.

By the way, does not the same defect exist in French clocks, and also in English weight clocks, only in a different manner? But I do not think that it would so much affect the rate of the latter.

If you wind an English weight clock with catgut lines quite tight up, the elasticity of the lines will act as a spring for a time, and greatly increase the power. I don't know whether stop-work is usually applied to all good regulators, but I fitted it to a new dead-beat movement I had made to answer for a regulator for myself for that very reason, and find it answers well. I have also found it an advantage to fit a bevel wheel to the winding square of regulator, and another on separate arbor to run in it at right angles, with a square on end, so as to wind the regulator through the side of case instead of opening the glass and running the risk of disturbing the hands. Besides, the hands are never in the way of the winding-hole.

I beg leave to submit to you what I thought perhaps a slight improvement on Mr. Schoof's plan for replacing broken cylinder. Perhaps I ought rather to say a slight variation of his plan, as I am no great authority in cylinder work.

Having a Geneva cylinder to fit in, I made a piece of brass something like the rough sketch sent, though the shape must depend partly on the shape of the sink where it is to be used.

To avoid the trouble of turning the bottom of cylinder, for the purpose of obtaining the right height of slit, &c., I fitted a screw into the temporary cock with a chamfer or countersink in the end, and placing the extreme end of cylinder arbor in it, I adjusted it to the exact height required, then turned shoulders, fitted balance, &c., and to get the exact length for top pivot, instead of a guage, I passed the end through one of the screw holes in top cock, which can be done when the bottom cock is off. If, as is mostly the case, the top cock is made to fit down tight on the top plate, you will have the right height by simply marking level with the top of cock through the screw hole. The only part, therefore, requiring measurement will be the length from top to bottom pivot, you can fit and try every other part before cutting off for bottom pivot.

There would be no trouble in making several holes in the temporary cock to receive the screw in different places.

Sundridge, Kent. J. VIRGO.

SIR,—I have read "Clerkenwell's" letter in your last with much interest, and I think a few more words may be said on the subject of keyless watches.

English going barrel watches, either keyless or not, usually have a small barrel—so small that when a mainspring of sufficient force to obtain a moderately large vibration is put in, it will scarcely go over 4½ turns, and as 4 turns are requisite for the stop work, there would be but half a turn left for the adjustment or setting up, and often not even that. If, then, we put keyless winding to this barrel, it will require more force to wind when nearly up, than it did when lower down; and, as the arc of vibration would increase considerably when wound, a little extra force would cause the striking of bankings "Clerkenwell" speaks of, as the wearer would naturally push harder in order to wind to the full, and some English barrel keyless work does require considerable force to reach the stop. I think if English makers could arrange their train work so as to allow for a larger barrel, they would obtain far more satisfactory results.

A Swiss barrel, with its 1½ or 2 turns of spring to spare, gives a good vibration to the last, has a more regular winding, and will not strike the bankings easily.

There can be no doubt as to the superiority of the fusee, both for equality of vibrations and regularity of winding; but I find the maintaining power work requires more careful adjustment than in ordinary winders, as the watch will sometimes stop several seconds during winding, which would be as serious an error in a good watch as that referred to by "Clerkenwell."

An indicator to going barrels would be a boon, and I trust some of the skilled horologers connected with the Institute will supply the want. LEMAS.

SIR CHARLES WHEATSTONE—to whom the Institute is indebted for many services, and who has just consented, at the request of Lady Burdett-Coutts, to act as one of the judges in our forthcoming Exhibition —has received from the French Society for the Encouragement of National Industry for his varied applications of electricity the great medal of Ampère, which is awarded every sixth year for the most important application of science to industry. The former awards have been made to de Lesseps, the engineer of the Suez Canal; to Boussingault, for his researches on agriculture; and to H. Ste.-Claire Deville, for his process for manufacturing aluminium. Sir Charles has also been elected Foreign Associate for the French Academy of Sciences, vacant by the death of Baron Liebeg.

To Correspondents.

"T W."—*Duplex watches and chronometers are in beat when the smallest possible angle of inflection of the balance sets the watch going. In the case of a duplex watch, draw the balance gently aside till the long tooth falls into the notch of the roller, and on releasing the balance suddenly the watch ought to go on. On being inflected the other way, till the tooth leaves the pallet, and let go, the balance ought to have sufficient swing to unlock again, and, of course, continue to go. If the watch goes on one way and not the other, the balance spring must be shifted accordingly. In a chronometer the testing points are when the tooth leaves the pallet on one side, and the unlocking pallet gets free of its spring on the other.*

"A. Z."—*Your proposition for up and down work applicable to a going barrel is, unless we misunderstand it, not practicable, for the pinion upon the star piece would carry round the wheel upon the barrel arbor (and, therefore the index) at the same rate as the barrel, less the amount that the star piece moves on its axis, or, practically, the index, instead of moving through a portion of a circle only, would describe three or four revolutions.*

"W. E."—*If the teeth of a Geneva barrel arbor are damaged a new arbor is necessary, unless you mean to spoil the watch. In order to recut the teeth, the arbor would have to be softened, and to be properly recut a machine is required, then, if recut, the ratchet will be reduced in diameter, necessitating the letting in of the click spring, by which the bar will probably be left too weak. In repolishing, the pivots will be reduced, and the time occupied would suffice to make a new arbor.*

To "M. I."—*I frequently have lever watches to repair that have a rattling or clicking sound in the escapement; this, I find, is generally owing to the roller-pin leaving the lever fork before the 'scape tooth has escaped from the sloped parts of the pallets. If it catches on one pallet only, I alter it by shifting the pallet on lever in the direction required, but when the defect is on both pallets, should the roller be replaced for one with the ruby pin further from its centre to obtain a larger angle, or should it be altered at the wheel and the pallets? What is the best way of making those nicely-shaped conical staff pivots? Are they made with a tool for the purpose? And what is the best medium for polishing same? Also, what is usually meant by a balance vibrating a turn and a half? Does it mean a circle and a half, as a lever or ordinary escapement could not possibly swing much over 360° without coming in contact with the lever, &c.?*—S. L.

British Horological Institute.

DIARY OF MEETINGS FOR SEPT., 1873.

DAY.	DATE.	TIME.	BUSINESS.
Tuesday	2nd	8.30	Council Meeting.
Tuesday	9th	8.30	*Journal* Committee Meeting.
Tuesday	30th	8.30	Finance Committee Meeting.

MEAN TIME OF THE SUN'S SEMIDIAMETER PASSING THE MERIDIAN OF GREENWICH, AND EQUATION OF TIME TABLE.—September, 1873.

Day of the Month.	Mean time of the Sun's Semidiameter passing the Meridian. M.	S.	Equation of Time *to be subtracted from* Apparent Time. M.	S.
1	1	4·2	0	12·0
2	1	4·2	0	31·0
3	1	4·1	0	50·3
4	1	4·1	1	9·9
5	1	4·1	1	29·7
6	1	4·0	1	49·8
7	1	4·0	2	10·0
8	1	4·0	2	30·5
9	1	4·0	2	51·1
10	1	3·9	3	11·8
11	1	3·9	3	32·7
12	1	3·9	3	53·6
13	1	3·9	4	14·6
14	1	3·9	4	35·7
15	1	3·9	4	56·8
16	1	3·9	5	17.9
17	1	3·9	5	39·0
18	1	3·9	6	0·1
19	1	3·9	6	21·1
20	1	3·9	6	42·1
21	1	3·9	7	3·0
22	1	3·9	7	23·9
23	1	3·9	7	44·6
24	1	4·0	8	5·2
25	1	4·0	8	25·6
26	1	4·0	8	45·9
27	1	4·0	9	6·0
28	1	4·1	9	25·9
29	1	4·1	9	45·6
30	1	4·2	10	5·0

*** Transit Circles are sometimes set to N. P. D. in preference to N or S Declination. Corresponding values have, therefore, been inserted in the Tables, together with the addition of Sidereal Time or Right Ascension.

J. J. H.

NORTH POLAR DISTANCE AND DECLINATION OF CERTAIN STARS, AND TIMES AT WHICH THEY ARE ON THE MERIDIAN OF GREENWICH.—September, 1873.

Star's Name and Magnitude.	Day of Month	N. P. D. / Declination, At Meridian Passage °	′	″	Sidereal Time / Mean Time At Meridian Passage. H.	M.	S.
α Lyræ (*Vega*) *Mag.* 1.	3	51	19	49·0	18	32	39·9
		N 38	40	11·0	7	40	38·9
	13	51	19	48·0	18	32	39·7
		N 38	40	12·0	7	1	19·6
	23	51	19	47.5	18	32	39·4
		N 38	40	12·5	6	22	0·3
ζ Aquilæ *Mag.* 3.	8	76	19	17·5	18	59	36·2
		N 13	40	42·5	7	47	51·2
	18	76	19	17·0	18	59	36·0
		N 13	40	43·0	7	8	31·9
	28	76	19	16·8	18	59	35·8
		N 13	40	43·2	6	29	12·7
ε Pegasi *Mag.* 2·5.	3	80	42	11·2	21	37	59·4
		N 9	17	48·8	10	45	28·0
	13	80	42	10·1	21	37	59·4
		N 9	17	49·9	10	6	8·9
	23	80	42	9·2	21	37	59·3
		N 9	17	50·8	9	26	49·8
γ Aquilæ *Mag.* 3.	8	79	41	32·9	19	40	15·4
		N 10	18	27·1	8	28	23·7
	18	79	41	32·3	19	40	15·3
		N 10	18	27·7	7	49	4·5
	28	79	41	31·9	19	40	15·1
		N 10	18	28·1	7	9	45·3
ζ Cygni *Mag.* 3.	3	60	17	22·9	21	7	34·1
		N 29	42	37·1	10	15	7·7
	13	60	17	20·9	21	7	34·1
		N 29	42	39·1	9	35	48·6
	23	60	17	19·2	21	7	33·9
		N 29	42	40·8	8	56	29·4
α^2 Capricorni *Mag.* 3·5.	8	102	56	8·3	20	11	2·9
		S 12	56	8·3	8	59	6·2
	18	102	56	8·5	20	11	2·8
		S 12	56	8·5	8	19	47·0
	28	102	56	8·7	20	11	2·6
		S 12	56	8·7	7	40	27·8

British Horological Institute.

THE Council have much pleasure in submitting to the Members the following Report as the result of the Students' work during the past Session:—

REPORT OF THE CLASS EXAMINERS.

September 12, 1873.

TO THE COUNCIL OF THE BRITISH HOROLOGICAL INSTITUTE.

GENTLEMEN,—As requested by you, we have examined the pupils in the Drawing Class, in order to ascertain those who are most worthy to receive the prizes proposed to be given to the successful candidates.

We have now great pleasure in reporting that, of the class examined, five pupils are particularly worthy of notice. With the exception of the first two—Nelson and Glasgow—who are practically equal, the names follow in order of merit:—

T. A. Nelson, } E. F. Mills, H. Hogan, and J. B. Walton.
D. Glasgow, }

The prizes at our disposal being three, and being of unequal value, we, under the circumstance of Glasgow and Nelson being equal in merit, have considered it necessary to recommend that the Silver Medal of the Institute be awarded to each of these pupils. That to Mills be given the Author's Edition of "Grossmann's Essay on the Lever Escapement," and to Hogan a Drawing Board and Square. Although to Walton we award no prize, we consider that he has made great and satisfactory progress, and bearing in mind the short time he has been under instruction, we feel confident that at the next examination he will take a higher place.

The drawings exhibited by Glasgow and Nelson were of great merit, Glasgow in this slightly taking the lead. In answer to the questions in Mechanics bearing on Horology Nelson took the lead, but it must be understood that little difference in either drawing or mechanical knowledge exists between these pupils.

Considering the nature of Mills' occupation, that of watch jewelling, his drawing and answers bear witness that he has not confined himself to the narrow bounds of a craft; and, as regards Hogan, he made up his deficiency in knowledge by his great industry in producing drawings.

Generally speaking, as regards the drawings exhibited, they bear ample testimony to the care which haa been bestowed on the class, and to the industry and intelligence of the pupils; and, as regards the questions given to the pupils, although in some cases they were unanswered, on no occasion did we receive vague or unsatisfactory replies.

We can only say, in conclusion, that we were much pleased with results of the examination, disclosing that at least in the case of two of the pupils a high standard had been reached.

We are, Gentlemen, yours, &c.,

G. W. FRODSHAM.
E. PERRETT,
(Signed) JOHN JAMES HALL.

THE LONDON JEWELLERS AND THE PLATE LICENCE.

CONSIDERABLE irritation has been felt by the retail jewellers of London at the recent proceedings of the authorities of Somerset House with reference to the Excise licence on gold and silver manufactured articles. Our readers will not need to be told that the licence is of two grades, the lower payment of £2 6s. per annum, allowing only of the sale of less than two ounces of gold or thirty ounces of silver; but should either of these weights be exceeded the higher duty of £5 15s. becomes necessary. The higher grade licence has hitherto been taken out almost exclusively by the large manufacturing goldsmiths, and makers of massive articles of silver plate, &c.; the shopkeepers dealing in small articles of jewellery considering themselves sufficiently protected with the ordinary licence of £2 6s. Some vigilant official of the Excise Department, however, having doubtless observed the growing fashion for heavy gold chains, has set to work to entrap the unwary shopkeeper, by sending an informer to purchase a chain exceeding in weight the regulation two ounces. The result has been that in several cases the unlucky shopkeeper has been rather heavily fined. Now, of the strict legality of this proceeding we have some doubt, for it has yet to be shown that jewellery of nine or twelve carat fineness can legally be held to be gold, or that a chain of plain gold wire, or a wedding-ring, can properly be denominated "plate;" but of the wisdom shown by the parties interested in declining to carry the case to the Court of Queen's Bench there can be no doubt whatever; such a course is too cumbrous and costly to be undertaken by individual tradesmen, and if the points in question are to receive authoritative decision the trade should unite and provide funds for the purpose. But the shopkeepers complain, and very reasonably, as we think, that if it was intended to enforce a stricter interpretation of the law, proper notice should at least have been given to every person holding a plate licence. Public officials in the discharge of their duties should be careful to avoid even the appearance of harshness, and respectable tradesmen of many years standing, who have paid this duty during the whole time they have been in business, should certainly not be at the mercy of a common informer. We are informed that the City shopkeepers received notice of the intended enforcement, and we know that the manufacturing jewellers of Clerkenwell were similarly cautioned; why, therefore, should not the same measure of justice have been extended to all? Moreover, the Commissioners of Inland Revenue annually issue a reminder of the time for renewal, and cases of the licence being allowed to remain unpaid, sometimes for as long a period as two months, are not at all uncommon. In view of these facts the National Chamber of Trade has resolved to wait upon the Chancellor of the Exchequer to represent to him the feeling of the trade with the view of obtaining a modification of the duty. We venture to think, however, that the time has arrived when the trade should make a determined effort to get rid of this impost altogether; for, apart from the gross anomalies surrounding the question, we never could understand why the gold and silver trades (properly so-called) should alone be subject to this licence, any more than many other trades producing articles of luxury or ornament, in some of which the precious metals are extensively used. The diamond merchant or lapidary may pursue his calling unmolested by the Excise officer, and why should not the watchmaker or jeweller? It is surely little less than monstrous that the almost priceless gem should pass free, whilst the comparatively worthless ring of gold in which it is held must not be sold without a "plate" licence. Dentists, we believe, are also free of the duty, though large quantities of gold are now used in that business, and quite as highly wrought as many articles of jewellery, if not more so. Indeed, the employment of gold and silver in one form or other enters so largely into the ordinary articles of every day use, that one has but to make the most cursory examination of the shop windows of the draper, stationer, fancy dealer, or electro-plater, to see at once the utter injustice and futility of confining this duty to the trades on which it is at present

. The fact is that by the march of manufacture the Act has become to a great obsolete in its action, as well as oppressive in its incidence. It would be difficult ermine if the duty were first imposed as a protection to the trade, or as a source of le; but, regarded from either point of view, it is now of so little moment as to be worthless, and we feel sure the time is not far distant when its chief apparent ons of annoyance and vexation to the trade will cease entirely. The National ber of Trade must agitate for its total repeal, and we doubt not but members of our throughout the country will gladly support the Chamber in its efforts. The vigorous ration of all concerned is alone needed to ensure the success of the movement.

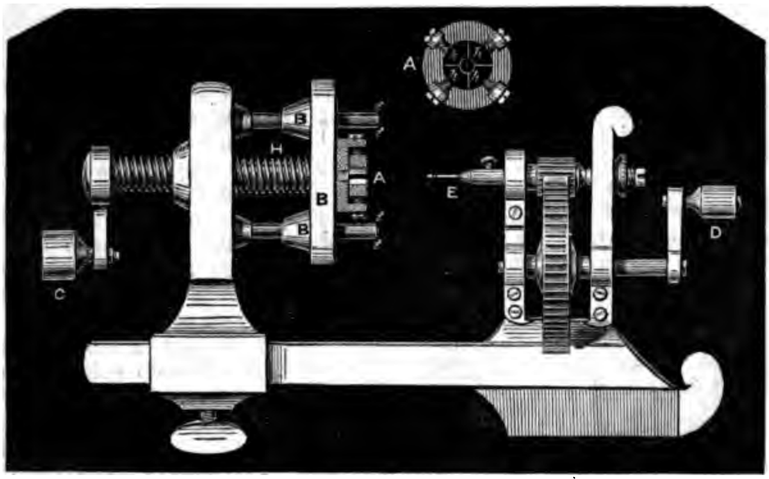
DRILLING MACHINE.

By M. Beillald d'Anet.

slated from the *Revue Chrometrique.*)

lrill, of which the following is a tion, is particularly suited for watch ockmakers, and is represented by the panying engravings.

Upon the disc *A* (of which the face is shown at *A'*) is placed the four pieces of steel *h h h h* for gripping the plate to be drilled. These slide in grooves, and may each be propelled or withdrawn by means of a screw, as may be required to suit the work to be acted upon.



disc *A* is mounted on the carriage *B*, slides upon four rods *t t t t* fixed to pet. The carriage is moved forward ning the screw *H* by means of the *C*. The drill *E* is set in motion by dle *D*.

ngle glance at the engraving will show plate of any thickness can be pierced eat speed and without loss of power. late to be drilled has simply to be on the disc upon a piece of flat wood pped between the four pieces of steel. ol dispenses with the bow, and as it to change the drill in the arbor, it work rapidly and well.

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stinguished Medallist.—The late Mr. S. Wyon, whose death, at an early age was recently announced, held the apnt of chief engraver of her Majesty's seals. The lately deceased artist was educated by his father, Mr. Benjamin Wyon, and in the Royal Academy of Arts, where he obtained two silver medals. His first work of importance was a medal of James Watt, the inventor of the steam-engine. This medal so pleased the late Robert Stephenson that, at his recommendation, it was adopted as an annual prize medal by the Royal Institute of Civil Engineers. The first work by the late Mr. J. S. Wyon, executed in his capacity as chief engraver of her Majesty's seals, was the Great Seal of England at present in use. In the year 1863 he executed a medal, struck by order of the Corporation of the City of London, to commemorate the passage of the Princess Alexandra through the City, previous to her marriage with the Prince of Wales, and in the year 1867 a medal for the same Corporation to commemorate the reception of the Sultan.

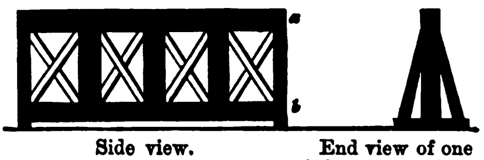
ON SYMPATHETIC INFLUENCE BETWEEN CLOCKS.

By William Ellis, Esq., of the Royal Observatory, Greenwich.

From the "Monthly Notices of the Royal Astronomical Society." *

It has been stated by clockmakers that clocks, if placed near together on the same wall or other support, will mutually influence each other, and in vol xli. of the *Philosophical Transactions* there are two papers by Ellicott, giving an account of the "influence which two pendulum clocks were observed to have upon each other." Lately, however, having to test a number of clocks at the Royal Observatory, provided for use in the observations to be made of the Transit of *Venus* in the year 1874, some curious instances of sympathetic influence came accidentally under my own notice, concerning which the Astronomer Royal has requested me to draw up, for presentation to the Royal Astronomical Society, a statement of the facts observed, since they appear to possess sufficient interest to make their publication desirable.

In order conveniently to rate at the Royal Observatory the clocks alluded to, a large and stout wooden stand was constructed, about eleven feet long and five feet high, along both sides of which the clocks could be ranged side by side. The stand is of the annexed form. The cross bracing (distinguished in the side



Side view. End view of one of the end standards.

view by not being shaded) was not at first supplied, and it was without these bracings that the stand was first used. Each clock-case was firmly screwed both to the upper and lower horizontal bars of the stand (*a* and *b* of the side-view sketch). When rating was commenced, two clocks only had been fixed, "Graham, No. 2," and "Arnold, No. 2," and it was soon remarked that there existed sympathetic influence, the difference between the times indicated by the two clocks remaining day after day constant. They were rated from 1872, May 2 to May 21, and an abstract of the rating is given in the following table:—

* The Council are indebted to R. A. Proctor, Esq., Editor of the "Monthly Notices," for the loan of blocks used to illustrate this paper.

1872.	Graham 2 fast of Sidereal Time.	Arnold 2 fast of Sidereal Time.	Graham 2 fast of Arnold 2.
	m s	m s	s
May 2	3 44·6	3 41·5	3·1
11	3 52·2	3 49·1	3·1
18	3 40·9	3 36·9	4·0
20	3 40·9	3 37·6	3·3
21	3 41·5	3 38·3	3·2
1	2	3	4

The numbers in column 4 show that the difference between the clocks was the same (3s·1) on May 11 as on May 2, comparisons on intermediate days, not inserted in the table, showing that this difference remained during the nine days constant. The clocks both gained in the same period 7s·6, or 0s·84 daily, and as the pendulum of one clock swung to the left, that of the other went to the right.

Now on May 11 the clock Graham 2 was stopped. The rate of Arnold 2 immediately changed considerably. Between May 11 and May 18 it lost 12s·2, or 1s·74 daily, or its daily rate changed, on the stoppage of Graham 2, from 0s·84 gaining to 1s·74 losing, that is, it *increased its losing rate by* 2s·58.

On May 18 the clock Graham 2 was again set going, but with its pendulum swinging now in the *same* direction as that of Arnold 2. That this was done is seen by the difference (in column 4 of the table) which was left 4s·0 instead of 3s·1. But on May 20 this difference of 4s·0 had become lessened to 3s·3, and on May 20 to 3s·2, showing approach of the pendulums to their former relative positions. The *rate* of Arnold 2 correspondingly returned to its former value: between May 18 and 20 it was 0s·35 gaining, but between May 20 and 21 it had become 0s·7 gaining. Or the starting of the clock Graham 2 changed the daily rate of Arnold 2 from 1s 74 losing to 0s7 gaining, that is, it *decreased its losing rate by* 2s·44. Thus a change of rate was produced in the clock Arnold 2 by a starting of Graham 2, in the opposite direction, and of nearly precisely the same amount as that produced by the stoppage of Graham 2. (Neither of the two clocks, on the starting of Graham 2 on May 18, took up its former rate at once, because of the disturbing effect introduced by setting the pendulum of Graham 2 into an opposite position relatively to that of Arnold 2, as mentioned. But between May 20 and 21 the clocks had about returned to their former state; the difference having become 3s·2 as compared with 3s·1, and the rate, 0s·6 gaining for Graham 2, and 0s·7 gaining for Arnold 2, as compared with 0s·84 gaining. The rating was discontinued on May 21.)

The wooden frame was now strengthened by the addition of the cross bracing before spoken of. On further trial of the clocks, no

: disturbing effects (as indicated by the rates) were perceived. Many other were afterwards fixed to the stand, and with others mounted each on a separate were simultaneously rated. Judging ir rates, all these clocks performed satisly. But in the course of time it became t that, whilst the arcs of vibration of the ums of *all* the clocks on separate stands ery uniform, those of *all* the clocks on at stand (at this time nine in number) l great variations, indicating that symic influence still appeared to exist, gh the effect was not now perceptible rates. To investigate this, all the on the great stand were for a week l, excepting one, and during this week ndulnm maintained a nearly constant The same thing was done as regards r of the clocks, with a like result. The were then all set going again, and ations of the arcs of three of them made quent intervals: one of the clocks d having an extreme losing rate, one reme gaining rate, and the other a rate ediate between those of the other two. bservations are contained in the following :

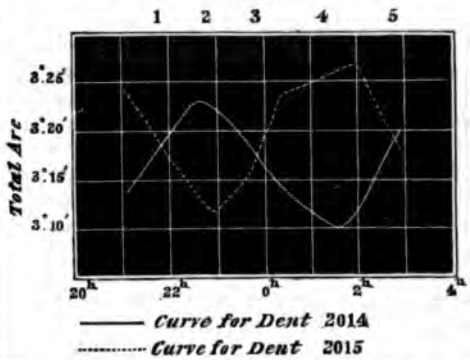
1873	Dent 2014 Daily Rate 8s·3 losing.	Dent 2011 Daily Rate 4s.1 losing.	Dent 2015 Daily Rate 1s.5 gaining.
d h m	(° ′)	(° ′)	(° ′)
eb. 27 21 45	2 57	3 53	3 19
22 45	3 7	3 47	3 9
23 0	3 9	3 45	3 9
23 15	3 12	3 42	3 10
23 30	3 15	3 41	3 11
23 45	3 14	3 35	3 15
28 0 45	3 8	3 21	3 29
1 15	3 5	3 15	3 31
1 45	3 1	3 10	3 29

ese numbers show that the arcs of vibravere in a state of rapid change, in nature lical, but that the effect produced by the bing action was different in each clock. udy the action more simply, all the were now stopped excepting two, Dent and 2015, and the following observations :—

1873.	Dent 2014 Daily Rate 1s·1 losing.	Dent 2015 Daily Rate 1s·4 gaining.
	Total arc of vibration.	
	° ′	° ′
d h m		
arch 4 21 10	3 14	3 34
22 30	3 23	3 14
22 50	3 23	3 12
23 43	3 19	3 16
5 0 25	3 14	3 24
1 35	3 10	3 26
2 0	3 12	3 27
2 50	3 20	3 18

relative change of arc is better seen in agram below.

the point 2 the two pendulums were ing simultaneously in opposite directions, and at the point 4 in the same direction, or at the point 4 the pendulum of the clock 2015 had advanced 1s·0 on that of 2014. Consequently between the points 1 and 5 the pendulum of 2015 had advanced 2s·0 on that of



2014; the interval occupied in making this advance being, according to the time scale of the diagram, from about $21^h\ 50^m$ to $2^h\ 45^m$, or about $4^h\ 55^m$.* Now, by the observed rates, given in the last preceding table, it will be seen that the clock 2015 was gaining 9s·5 daily on 2014; it should, therefore, advance 2s·0 on 20 14, in $24^h \times \frac{2}{9\cdot5}$, or $5^h\ 3^m$, which result differs by a few minutes only from that found from the diagram. In this mutual action of two pendulums there is another circumstance to be remarked, which is that, in the alternate variations of arc, as one pendulum attained its *greatest* arc, the other reached its *least* arc.

This simple experiment with two clocks shows clearly the dependence, in a case of mutual disturbance, of the variations of arc on the difference of rate, the period in which in each clock the arc goes once through all its changes corresponding to the advance of one pendulum on the other by one complete vibration (or 2s).

It appears, therefore, that the pendulums of two clocks, fixed to the same support, tend to influence each other, in degree, according to the facility with which the support can be put into or communicate vibration, and further, that

(1) The influence may be imperceptible to ordinary methods of observation;

* A little inequality is introduced into the diagram from the fact of the mean value of arc for Dent 2015 being a little greater than that for 2014. In strictness the dotted curve should be lowered by about 4′, which would shift the points of intersection 1 and 5 a little to the left, and the point 3 a little to the right, thereby rendering the spaces between the several points equal, without affecting the absolute distance between the points 1 and 5.

(2) Or may be perceptible only as affecting the arcs of vibration in a lesser or greater degree;

(3) Or may be sufficiently powerful to cause the clocks to move entirely in sympathy.

In the practical use of clocks, cases (1) and (3) will never cause error; in the one instance no injurious effect would be produced, and in the other the effect would soon be perceived. But not so with case (2). For the variations of arc would usually cause small alternate accelerations and retardations in the time, which, in the daily rating of an ordinary clock, might not be distinguished or separated from other greater sources of error (as was the case with the Transit of *Venus* clocks, after bracing the wooden stand, on which they were temporarily placed for trial, as before mentioned). No doubt, however, if a clock, supposed to be so influenced, were compared very frequently, by some accurate method, with another independent clock (suppose by coincidence of beats, using an intermediate chronometer), the inequality of rate would then be perceived. Such inequalities, even if small in magnitude, being of periodical character, might affect injuriously any delicate experiment and would be especially mischievous in any clock used for very accurate or fundamental work. Examination of the arc would, however, always reveal the existence of disturbance.

Some apology may be necessary for the length of this paper, but I have thought that, in a matter of experiment of this kind, it was desirable to give an account of the phenomena observed in some detail.

Nearly three thousand persons in Geneva are occupied in the jewellers' and watch-makers' business, and twenty thousand watches are made annually. The restrictive duties laid upon these manufactures by neighbouring countries, and especially by France, have led to a regularly organized system of smuggling, from which the government agents appear to derive a private revenue, and which is, therefore, very difficult to break up. It is said that a prefect of police of Paris, having bought at Geneva jewellery and watches to a considerable amount, the tradesman offered to deliver them in Paris for an additional sum much below the cost of carriage and the duties. The prefect made the agreement, and gave notice at the frontier custom-houses, describing the articles, and requiring even more than usual vigilance. The articles were, nevertheless, delivered to him according to contract, and on investigation he found that they had passed the frontier in his own baggage.

CLOCK BY DR. FRANKLIN.

By R. J. Lecky, Esq.

This clock was made about the year 1819 for Roger Dartnell, Esq., M.D., Youghal, Co. Cork, and was used as his sidereal clock, in his Observatory, on the town wall of that place, until his death, in 1832, when it came into my possession by bequest from him.

It is, I believe, the simplest form of a really useful clock ever contrived, and is described in Rees' *Clydopædia*, article, "Clock," and figured in the plates of *Horology* as invented by Dr. Franklin; but Dr. Rees does not give his authority for this. He also gives another of somewhat similar construction by Ferguson, but not so simple as Franklin's. The train consists of only three wheels and two pinions. The great or centre wheel has 160 teeth, driving a pinion of 10 leaves on the arbor of the intermediate wheel; this has 120 teeth, driving 8 leaves on the 'scape wheel, which is of the ordinary kind, and has a simple "Graham" dead-beat 'scapement, not jewelled. This wheel, of course, carries the seconds-hand in the usual way; and the great wheel, which revolves in four hours, carries a hand which denotes both minutes and hours, the periphery of the dial being divided into 240 minutes, and each of the four quadrants consecutively numbered 0 to 60. Each quadrant, therefore, represents three hours, within which time it is requisite to know the hour; and herein consists the greatest drawback to the usefulness of this form of clock. This, however, might be easily remedied by a 12 or 24-pointed star and divided plate or hand set forward by four pins in the great wheel. The driving-wheel simply acts on a grooved pulley fixed to the arbor of the great wheel, as in a common Dutch clock, and has a maintaining spring and ratchet to keep the clock going while being wound. Mounted in this way it would require to be wound daily; I have, however, added a weight and counterpoise, fitted as double-sheaved blocks, the sheaves being contained in the body of the weights, which enable it to run for eight days; and by making the string endless, and passing it over a winding pulley, it acts as a "Huyghens pulley," thereby rendering the maintaining spring useless. The driving-wheel is eight pounds, and the counterpoise four, the effective power, therefore, being 4lbs.; and as this is divided on to four strings, the actual weight which propels the clock is only 1lb., minus the friction of the pulleys. This gives the pendulum a swing of 3° 10′, the angle of escape being 1° 24′ (or 42′ at each side of zero); the excess being,

therefore, 1° 46′ (or 53′ at each side). This excess is increased 14′ by using a single string with 1lb. driving-weight, instead of the four sheaved blocks, owing to the decreased friction.

In a series of experiments on the swing, the clock being fresh cleaned and oiled, with weights increasing from 3¼oz. up to 32oz., I found that at this lower weight the clock would not go, but with 3¾oz. it went, the swing being 1° 32′; with 4oz. the swing was 1° 38′; 5oz. 1° 56′; and the average increase of swing being from 5 to 8oz., 12′; 8 to 12oz., 9′; 12 to 16oz., 6′; 16 to 24oz., 4½′; and 24 to 32oz., 3′; the full swing being at this latter weight 4° 36′, or 2·18 at each side zero.

The pendulum is an ordinary Graham's quicksilver compensation. The rod is of the finest cast steel, and the bottle a piece of 2-inch cast-iron pipe, bored and turned, the top and bottom being wrought-iron. The rod passes through and is screwed into the latter, with a counter-nut and pointer below. The adjustments for both rate and beat are at the top, and can be used without stopping the clock. The screws for adjusting the beat move a slide which carries the pendulum; and one of them, that on the right-hand side, impinges on a loose brass piece which pinches the pendulum-spring against the edge of the slide, thereby always retaining it at the same point of suspension. The screw for adjusting the rate moves the pendulum-spring between this loose piece and the main slide, the right-hand beat-screw being first loosened; and the spring is suspended to its screw, as well as attached to the top of the pendulum-rod by pins passing through a centre line, thereby avoiding unequal tension to the edges of the spring, which is the constant cause of breakage. There is also a clamping screw to the spring at the top of the pendulum, but this is not tightened until the pendulum has found its true position.

I added an anti-friction crutch to the pallets, which I believe to be an essential benefit, although seldom adopted. It allows for the friction arising from the point of suspension of the pendulum and the centre of motion of the pallets not being in the same right line.

The case in which this clock is mounted is composed of slate slabs, the back being a single slab 1¼ inches thick, and to this the pendulum is suspended independent of the rest of the clock. The weight and rigidity of the slate give it great stability, and the clock goes with great steadiness; is very readily adjusted; and if a minimum of friction be a desideratum, I think this mode of construction possesses it more than any other.—From *Monthly Notices of the Astronomical Society*.

ON THE MAKING OF A NEW BARREL-HOOK.

Every repairer of common English watches is well aware of the difficulty often experienced with the barrel, in consequence of the very strong main-spring breaking, and also because of the weakness of the barrel itself, which is aggravated by the large hole for the hook. The barrel gets bulged or forced out of shape, whereby the cover is loosened. This is such a common occurence in the cheap work, that a tool has been invented to bring the barrel back to shape, if I have properly understood the object of a tool described by an American writer as a barrel-closer. To lessen the evil, I would recommend for such watches a solid hook, screwed into the barrel, instead of a hook rivetted to the main spring. Having seen very often a bad attempt made to put a hook in properly, I beg leave to submit the following mode of proceeding:—

Drill a hole into the barrel, in size about one-third the width of the main spring, and tap it. Now screw a piece of hard brass pin wire into the corresponding hole of the screw plate, making the screwed part about a quarter of an inch long; nip the wire off, leaving a sufficient length on the opposite side of the screw plate, to form the hook in the thicker end of the wire. The hook should be nicely squared, undercut, and finished to a thickness equal to about 1½ that of the main spring before it is removed from the screw plate. When the hook is completed, lay hold of the screwed end with your pliers, screw it from the plate and fit it into the barrel from the inside. Done in this manner, any workman will see that a much cleaner and stronger job will be the result than by the mode of screwing the hook in from the outside. Care, however, should be taken that the tap is easy enough to allow the hook to screw right home without fear of breaking. W. G. SCHOOF.

Gold in Crowns and Half-Crowns.—The Deputy-Master of the Mint states in his report recently issued that much of the worn silver coin in course of withdrawal from circulation, contains gold in sufficient quantity to render its extraction profitable, under the present improved methods of refining. Last year worn crowns and half-crowns withdrawn from circulation, weighing 117,938 ounces, were subjected to the process of refinage, in order that the gold contained in them might be extracted before they were melted for re-coinage, and 81.27 ounces of gold were recovered. No refinery being now attached to the Mint the operation was performed by Messrs. Johnson, Matthey, and Co., for a charge which left a margin of profit sufficient to justify the Mint in the course pursued.

THE DIAMOND AND OTHER PRECIOUS STONES.

By M. BABINET, of the Institute of France.

(From the "Smithsonian Report" for 1870.)

The diamond, called by the Greeks "adamas," from its hardness and infrangibility, has attracted the attention of amateurs of precious stones from the most remote antiquity.

In regard to hardness, says Lucretius, diamonds are placed in the first rank, as they resist the blow of a hammer.

> "Adamantina saxa
> Prima acie constant, ictus contemnere sueta."

The second of these peculiarities is much more easily contested than the first; for notwithstanding all the fabulous assertions of ancient authors, the diamond, which scratches on all bodies and can be scratched by none, is easily broken by percussion, and is susceptible of *cleavage*, that is to say, of being readily divided by pressing steadily the sharp blade of a steel instrument in the direction of the natural seams of the stone.

When the rude Helvetians captured the treasures which were found in the tent of Charles the Bold, more sumptuous than those of the King, they divided with their hatchets some of the diamonds of this prince, to the great detriment of their value, as the entire stones were worth much more than the pieces into which they are divided. If we examine the many compilations from the ancients, made at the time of the Renaissance, we shall find a mass of undigested learning on the subject of gems. Notwithstanding the uncertainty of the names which he applies to many of the precious stones, Pliny is still highly esteemed as a compiler from ancient works now lost, and as an author of the first class. It was he who dared to undertake the composition of a history of nature analogous to what had been done before his time in regard to nations. The term *natural history* has become so familiar to us that the idea conveyed, namely, a history of all things that contribute to make up a world, minerals, vegetables, and animals, has almost entirely lost the original magnitude of its signification. And in this connection it is worth while to pause for a moment to remark that science in its progress, as it has become more real and important, has gradually become more and more modest. Where, as with the Greeks, the word nature, *physis*, signified the generation or origin of beings, with us it is restricted to the system of objects that constitute the physical universe, and is not applied to the occult cause by which they were produced. Here, as everywhere else, science, in order to make real progress, has abandoned ambitious metaphysical speculations for sagacious observations, and wild hypotheses for sober facts.

It would be interesting to trace the history of gems in connection with the history of man, from the times of Aaron's ephod to those of the pastoral cross of the Archbishop of Paris; from the time of the presenting of rubies, sapphires, emeralds, diamonds, topazes, sardonyxes, amethysts, the carbuncle and loadstone, as offerings in the temple of Jupiter and other pagan divinities, to that of an accumulation of wealth of a similar character, prior to the sixteenth century, in the treasury of Christian churches.

But, without attempting this labor, we may observe, in passing, that these precious gifts, the offerings of the piety of the faithful, have not always been faithfully preserved. When, during the reformation of Calvin and Luther in Germany, and later, in the time of the French revolution, this votive wealth was delivered over to the civil authorities, it was discovered that many fraudulent substitutions had been made, and that paste had very often been substituted for the primitive gem.

The famous London Exposition of 1851 prided itself upon the possession of the great diamond, the Koh-i-noor, (Mountain of Light,) captured from the Maha-radjas of India, and presented to Queen Victoria. As to the antiquity of this gem, it is asserted that it was worn by Karna, King of Anga, three thousand and one years before our era. Observe the preciseness of this date. I have nothing to offer in objection to it, and am even ready to grant the truth of the assertion; for who can prove the contrary? We can say, however, quite as much in behalf of the truth of the marvellous properties ascribed to precious stones by antiquity and the middle ages, and admit without hesitation, as they have done, the influence of the planets and other celestial bodies. For the cure of all diseases of a moral or nervous character, wherein the imagination exercised a predominant influence, gems were the sovereign remedy. In declaring to a patient that an emerald, placed at the head of his bed, would cure hypochondria, drive away nightmare, calm palpitations of the heart, enliven the imagination, or dissipate mental troubles, success was assured by the faith alone in the efficacy of the remedy. The expectancy of cure in these affections was itself the cause of the cure, and in all of the countless cases in

which the moral exercised an influence over the physical, an imaginary cause must produce a real effect. In short, a constant tendency to self-deception of the human mind, which leads us to regard only accidental successes, and to take no note of failures, contributed to maintain the belief in the hidden virtues of precious stones. It is not above half a century since diamonds and other gems were borrowed from rich families to be applied in the cure of local diseases. Care, however, was taken when the jewel was introduced into the mouth, for toothache or sore-throat, to secure it by a string, to prevent its being swallowed by the patient.

The study of precious stones, which may seem frivolous when these are considered only as objects of ornament, rises in importance when looked upon in connection with commerce, optics, and mineralogy. The classic Haüy, creator of crystallographic mineralogy, has not disdained to publish a book on precious stones, in which he leaves nothing to be desired in the way of description. In his preface he acknowledges his obligations to M. Achard, mineralogist and lapidary, of Paris; and I ought to say as much for M. Achard, the son, without whose aid I should not have felt able to compose this article.

What is the diamond? It is the most rare and the most priceless of minerals. What is carbon? It is one of the most common of known substances, found in the earth in immense quantities, and furnished by all plants and trees in great abundance. The diamond is priceless, since one of pure quality, of the weight of a twenty-five franc piece—that is, of 125 carats—will have a money value of at least four millions of francs. Now, the value of an equal weight of carbon is scarcely anything, and yet the two are identical; the diamond is only carbon crystallized. Every one knows that if a body is dissolved into a liquid—for example, common salt, saltpetre, sugar, or alum, in water—the deposit left by evaporation of the liquid will present regular geometrical forms. Salt assumes a form identical with that of playing dice, to which the Greeks gave the name of cubes; saltpetre presents elongated bodies with four flat sides and square ends; sugar takes the form known as rock-candy; and finally alum crystallizes into pointed pyramids. This latter form is precisely the same as that under which nature presents us with the crystals of carbon called diamonds.

As soon as the character of the diamond was discovered, chemistry aspired to emulate nature in producing the gem from carbon; but up to this time science has been baffled in her attempts—nature has not been induced to reveal the secret of her process. These geometrical products of nature, when not worn by attrition, are as smooth and as polished as the finest cut glass. Coloured crystals are also produced by nature as well as white ones. The red ruby, the blue sapphire, the green emerald, the yellow topaz, the violet amethyst, and the crimson garnet are all the products of her unrivalled laboratory.

Chemistry, it is true, furnishes us with hundreds of crystals of different forms, according to the character of the substances of which they are composed, and many of them are not found in mineralogy. Nature, however, as if by way of revenge, has produced, in the course of ages, and under the influence of actions scarcely as yet recognized, crystals which art, directed by science, has not been able to imitate. Such is emphatically the diamond, and many other minerals not embraced among gems. To the study of these geometrical forms, whether the products of nature or of art, the celebrated Haüy, about the beginning of this century, gave many years of his life, and out of this study created a new science, one of the titles to glory of the human mind.

Pythagoras and Plato had without doubt given attention to crystal-lography, since in their schools they announced the marvelous proposition that nature, in the depths of her recesses, occupies herself with geometrical problems, and that God *geometrizes incessantly*.

The old alchemists contended that the philosopher's stone could be produced from the commonest substance possible, and nature seems to have favored this idea in producing the most costly gems from the most worthless materials. She converts, as we have seen, a small quantity of black and friable carbon into a transparent diamond of a hardness and brilliancy unequaled. She takes a little of the glazing which the potter uses in his ordinary operations, and, coloring it with a trace of iron, produces a ruby or a sapphire. From a little worthless pebble, with slight additions, she forms the topaz, the emerald, and the amethyst. Some of the last-named gems have been reproduced in the furnaces of Sèvres in the same manner, without doubt, as nature has elaborated them in her vast volcanic workshops, by those mysterious operations which have given to Vesuvius the title of the great crystal manufactory. Every one knows of the sarcasm with which Rousseau reproached the chemist Rouelle, demanding of him that he should produce corn from the chemical materials of which it was composed, rather than destroy that already made in its analysis. What would he say if he had seen the chemist produce carbon from the diamond, as readily as from a bit of wood or sugar,

while he was powerless from the carbon to create the precious gem?

It might seem at first sight that those countries containing diamond mines, or mines of crystallized carbon, were the most favored; but this is far from being the case. The mines of Golconda, and of Visapour in India, of Brazil, of the Ural, and of Borneo, are not worth a moiety of those deposits of coal with which nature, a little parsimonious in regard to France, and still more so toward the vast territory of Russia, has endowed Belgium, England, and to an immense extent the United States.

By way of illustration, we can state that England, with all her wealth, does not import precious stones of a value greater than twelve or thirteen millions of francs, while her mines of coal yield a value of five hundred millions of francs per annum. How precious is this coal!

The diamond is commonly found imbedded in a sort of reddish cement. Sometimes the rock containing them requires to be broken, and often the sand at the base of torrents, or the earth which has received the waste of diamond-bearing rocks, is gathered, and submitted to frequent washings by machinery, to exclude the gravel and stones prior to the hand-washing which secures the gem.

Diamonds are always found covered by a rough coat, which is, in fact, the product of the chemical action of the crystalline formation. Nearly all the other crystals, and especially those of quartz, are much more brilliant in their natural state. Had Socrates, who regarded the natural man as a block of marble, from which art can create a beautiful statute, known of the transformation created by the cutting of the rough diamond, he would certainly have preferred this comparison. The difference, however, in money value between the cut and the uncut diamond is not so great as might be supposed. For if the rough diamond loses half its weight by cutting, on the other hand, its value is doubled by the operation, without estimating the dust remaining, which has a value in the arts from its being employed in polishing many gems as well as the diamond itself.

The ancients do not appear to have had a suspicion that the diamond could be cut. They only knew it in its natural condition as a stone, having eight triangular surfaces, and in every direction presenting a double pyramid.

Louis de Berqueu, an artist of Bruges, about the middle of the fifteenth century, conceived the idea of cutting it, at first by rubbing two diamonds one against the other. If, in fact, we cement two diamonds on wooden handles, and rub point against point, we shall, little by little, grind them away, and obtain an artificial unpolished surface. To polish this surface we must use a circular plate of steel or of cast iron, like a grindstone, placed horizontally. But it is easy to see that if a diamond is merely placed against this grindstone, it would require a century to produce a polished surface. All that can be obtained by this process are grooves cut in the iron or steel. To effect the desired object, a happy thought suggested itself to Berqueu, to sprinkle the surface, against which the diamond was rubbed, with diamond dust mixed with oil. The surface obtained in this way is regular, smooth, and perfectly polished. After the discovery that facets could be produced in the diamond, experience indicated in each case how a particular stone should be cut to produce the most advantageous effect.

There are two principal styles of cutting. The first is called the *brilliant*. In order to produce this style, the diamond to be cut must be pointed. If not naturally in this form, it must be reduced to it artificially. The points on the upper surface are ground down a little more than one-half, and those on the lower or under surface one-eighth. Then the light, entering through the larger upper surfaces, strikes the bottom surfaces, is reflected back, ward, traverses the side facets, is refracted- and produces prismatic effects. Every one knows what is the result when white light is decomposed into the colors of the rainbow, and coming to the eye, with every variety of hue, produces what is called the lustre of the diamond. For this effect the light should not be voluminous, for there might be neutralization of these colors, and white light be reproduced. Nor should the facets be too large, for then the eye would receive all these colors at once, which would also reproduce white light.

The large diamonds, the Regent, belonging to the crown of France, and the Koh-i-noor, belonging to that of England, are cut with facets too large, and not sufficiently numerous. It would have been better if the large upper surface, called the *table*, had been cut in a series of smaller facets, made to slope towards the edge, as is done for small colored stones.

The following is my method of studying the effect of a diamond: I pierce a hole in a white card a little larger than the diamond to be examined. Then passing a ray of sunlight or that of the electric lamp through this hole, I place the stone in the path of this ray, at a certain distance from the hole, behind the card, so that it shall receive the light on the table of its anterior surface. The rays reflected from the table, and also those which pass through into the diamond, are reflected back

on the card, where they exhibit a white image of the table, surrounded by small bands iridescent with all the prismatic colors. Now, if the colors are considerable in number, well separated, and equally spread around the white reflection of the table, the diamond has been well cut. Each of the bands indicates one of the lustres of the stone, which may therefore be counted, and, consequently, in this way, the number, the quality, and the symmetry of the lustres can be determined; errors in cutting can be detected; and the form to produce the best effect can be ascertained. I have always intended to undertake by this method the study of the principal diamonds of France, but have always postponed it, being, like Homer, too much pressed with other work.

The second kind of cutting is called, for what reason I know not, the *rose*. It consists in leaving a large, smooth surface underneath, and in covering the upper surface with a great number of small facets, in order to produce on the face, by the reflection from below, lustres and colors similar to those of the brilliant. This cutting is used for stones of a flat form, the weight of which would be too much diminished in reducing them to the form of the brilliant. In this manner the great Indian diamond of England was originally cut, before it was presented to the Queen; in cutting it as a brilliant it has been reduced from 186 to about 103 carats. It is scarcely necessary to say that, by the process I have given, the rose-cutting can be as well verified as that of the brilliant. In both, large facets should be avoided even for the larger diamonds. As to the identity of the diamond known as the "Saucy," the name of one of the captains of Henry the Fourth, there is no agreement among connoisseurs. All the diamonds which pretend to this name weigh from 55 to 70 carats, and are cut in the form of a flattened pear, almost round, a shape called the *pendalogue*, having facets above and below, with a small, flat surface on the top. Several imitation diamonds cut in this style have given admirable effects, and I think that it should have been adopted in the cutting of both the crown diamond of England and the rough diamond, known as the *Star of the South*, presented to the Academy of Sciences by M. Dufrénoy. This kind of cutting, which I venture to call the *Sancy*, merits as much attention as those known by the name of the *rose* or the *brilliant*. If from a single luminous point, multiplied by facets, we obtain several colored lights, it is evident that from a number of luminous points more splendid effects will be produced. For this reason the light from a number of wax candles or from uncovered jets of gas is more favorable to the brilliancy of the diamond than that from lamps or gas inclosed in globes of ground glass. Therefore those who sell diamonds would do well to remember that if in exhibiting them they substitute for the one or two large lamps frequently employed, candelebra containing a number of wax candles, the character of the gem will apparently at once be changed, and it will resemble in brilliancy that grouping known as the *parterre* or *basket of flowers*.

Whenever I have been invited to see an amateur collection, among which there was one princely diamond, (that is, above 10 carats weight,) I have often give the owner great and unexpected pleasure by lighting on a mantle-piece from eight to sixteen wax candles, thus calling forth, as it were, all the latent splendour of the gem. The reflection in the mantle-mirror doubles the number of candles; and if we turn our back to the mirror while holding the diamond in the hand, about the level of the eye, and vibrating it rapidly, the most beautiful effects are produced. If this secret had been known to Prince Potemkin, who enjoyed like a Sybarite the company of his beautiful diamonds, he would have obtained a much higher pleasure from his favourite contemplation. In the splendid apartments of the Tuileries nothing is more easy to remark than the great difference between the brilliancy of these gems in the rooms lighted by wax candles, compared with that obtained in those where gas-jets are inclosed in ground glass globes. Walking, dancing, every movement of the body, however slight it may be, varies very perceptibly the ever changing play of the lights of this transcendently beautiful gem.

It is remarkable that the price of diamonds has remained invariable for several centuries. A perfect diamond, weighing one carat, is worth about 200 francs. Double this weight, and you quadruple the price, which is as the square of the weight, so that one weighing 10 carats would cost 10+10+200, or 20,000 francs, which would be more than that of a first-class *solitaire*. Though it does not enter into our plan to speak of the arrangement of diamonds, and the best manner of setting them, which is properly the business of the jeweler, we will say that recently, admirable effects have been produced, at a great saving of cost, in substituting for one very large stone a diamond of more moderate dimensions, surrounded by eight brilliants of one carat each. Suppose we have for the middle stone of the necklace a diamond of four carats, worth 3,200 francs, surrounded by eight stones of one carat, worth 1,600 francs. We get for 4,800 francs an effect equal to that of a 10-

carat diamond, which would cost from 20,000 to 25,000 francs.

The mines of India, at Golconda, Raolconde, Visapour, held for a long time the monopoly of the diamond market of the world. Of late, however, Brazil has added its productions, which, having almost always a slight yellowish tint, contrast finely with the diamonds of India. It is from Brazil, at present, that nearly all the diamonds sold in Europe are obtained. These are first sent to Amsterdam to be cut, thence to Paris and London to be set, and thence they find their way through commerce to every part of the world. Borneo also furnishes a few hundred carats of diamonds. Humboldt conjectured that, from their formation, the Ural Mountains ought to produce diamonds, and research has justified his prediction. It does not appear, however, that these deposits have even yet been made productive in the way of regular mining. Algeria, also, has had the reputation of producing diamonds, and we have seen, in the possession of amateurs of mineralogy, specimens said to come from this locality; but whether these came from a real or supposed deposit, they have had no place in commerce, and the same may be said of the Californian and Australian diamonds. In general, the proportion of diamonds in circulation augments with that of the population that can afford to purchase them, which causes their price to remain nearly the same at all times. A panic due to the discovery of some new diamond beds in Brazil, about the year 1845, caused a temporary fall in the price of this gem, but the equilibrium was soon restored, and now, at London as at Paris, a diamond of one carat is worth the old price of 200 francs, more or less.

The number of stones which surpass in weight 100 carats is extremely limited. It is estimated that among 10,000 diamonds only one will be found weighing 10 carats, and consequently this will merit the name of *princely*. Russia, France, Tuscany, and England possess diamonds weighing over 100 carats. By far the chief among these, on account of its beauty, is the Regent, so called because it was to the Prince Regent that England owed its acquisition. All these large diamonds come from India. The Star of the South, of which we have just spoken, and which was shown to the Academy of Sciences January 3, 1856, came from Brazil, and was obtained from one of the new mines, the discovery of which caused the transitory depression of the diamond market. It was found in July, 1853, and weighed 254½ carats. This gem appeared perfectly limpid, and without tint which has been the reproach of Brazillian diamonds. The cutting of it as a *brilliant* reduced it to half its original weight, which will make it about the same as that of the Regent, which is 136¼ carats. To have cut it in the form which I call the *Sancy*, would have left it three-fourths of its original weight, and have given it a much more splendid luster. When I wished to suggest this the diamond had already been sent to Amsterdam. It was exhibited at Paris in the great exposition of 1856. It is estimated to weigh 127 carats. It is one of the five diamonds to which the name of *sovereigns* has been exclusively applied. Everything indicates that the number of these peerless minerals is extremely restricted, since so few have rewarded the arduous labor of searching for them.

THE MANUFACTURE OF BLACK FOREST CLOCKS.

This industry which two centuries ago was confined to the production of a small number of very rude clocks has steadily expanded till it has become one of the most important manufactures in Germany. In 1796 the number of clocks of all descriptions made in the district was 7,500. In 1808 the number had risen to 20,000. In 1862 the total was 1,000,000, and in 1872 was produced the astounding number of 1,800,000 clocks, of almost infinite variety, from the low priced antiquated wooden movement going only 12 hours to the costly modern regulator, and embracing specialities for nearly every country in the world. 400,000, or nearly a fourth of the whole, were made at Furtwangen.

The greater number exported to Great Britain are provided with weights and chains and go 24 hours. Switzerland is a customer, principally for trumpet and cuckoo clocks. The demand in Austria is for the better class of chain clocks, while Italy takes scarcely anything but spring clocks.

France has a predilection for those of a large size, which are sold under the name of Swiss clocks.

To Belgium and Holland are sent clocks with bronze cases ornamented with tin and porcelain shields.

Russia is a large customer for the best 8-day clocks, and is also the depôt from which some of the Asiatic countries are supplied with the Black Forest manufactures. Turkey and Mallacca have ship's clocks as well as cuckoo. Sweden, Norway, and Denmark shew a preference for sexagonal and octagonal cases. Spain and Portugal take chain clocks only. Even the United States, where great

attention is paid to the manufacture of cheap clocks, imports Black Forest goods largely, chiefly cuckoo clocks and regulators. Mexico and South America take a fair proportion of cuckoo and spring clocks. India, China, and Japan demand cuckoo and ships' clocks, and a better manufacture, with cases after the English patterns.

There are in the district 1429 clock manufacturers, employing 7526 hands, but it is computed that altogether 13,500 people are dependent upon the clock trade. Even with the whole world for a market, the distribution of two millions of clocks a year is an achievement that the founders of the Black Forest clock trade could certainly never have anticipated.

KRAUTH'S PATENT UNION-CHRONOMETER ESCAPEMENT.

NEAR the periphery of the escape wheel (A), and lying in a plane parallel thereto is a lever (BB.) On each side of the fulcrum on which the lever works, is a three-cornered ruby pin *d* and *e*. The two pins being situated at a distance from one another somewhat less than that between the two adjacent teeth of the escape wheel.

The axis of the balance wheel carries a roller (C) somewhat similar but smaller than the roller of a chronometer escapement. The said roller having a recess or depression, in which the teeth of the escape wheel enter and strike against one edge of the said depression, and give consequently the required impulse to the balance wheel.

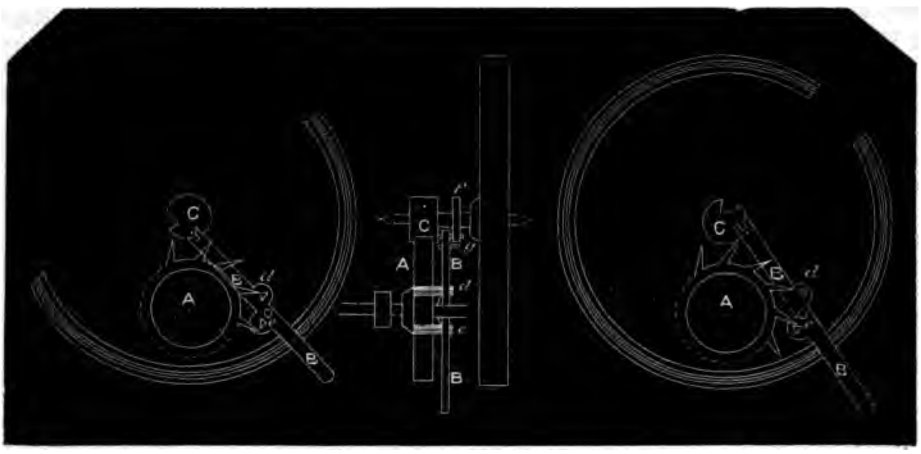
The end of the lever (B B) forms a fork similar to that of a common lever, and is guided by a roller like an ordinary lever.

The action of the parts is as follows:—By the motion of the balance wheel the ruby pin *g* on the roller *f* (best seen in Fig. 2) engaging in the fork lifts the fork end of the lever and permits a tooth of the escape wheel, which was bearing against the pin *d* on the lever in Fig. 1, to escape, the said tooth being arrested by the pin *e*, which, by the motion of the lever, has been brought within the range of the teeth of the escape wheel pictured in Fig. 3. It is by the lifting of the lever, and the permitting of a tooth of the escape wheel to escape, which was bearing against the pin *d*, that motion of the escape wheel is permitted, and to cause the striking of a tooth against the edge of the recess in the roller. On the return motion of the balance wheel the pin *g* on the roller *f* communicates a contrary motion to the lever, allowing the tooth which was bearing against the ruby pin *e* to escape, and the next tooth before it to bear against the ruby pin *d* (Fig. 1.) The motion in this case being very slight. The balance wheel starting on its second advanced motion receives the second main impulse as already described, and so on.

The shape of the surfaces of the ruby pins *d*. and *e* on the lever B B, against which the ends of the escape wheel teeth act, is such that the said teeth in escaping under the pins *d* and *e* give the impulse to the lever in the required direction, although the balance wheel is started by the main impulse received on the recess of the roller C. The result is that the escape wheel retains all its power, such as it receives from the main spring, and uses it both upon the balance wheel itself and the lever. The essay of the described new escapement is most satisfactory.

F. T. KRAUTH.

Fig. 1. Fig. 2. Fig. 3



NOTE.—*The escape-wheel has twelve teeth only.*

Letters to the Editor.

All letters to be addressed to the Editor, at the Institute, 35, Northampton Square, E.C.

Sir, — The constantly-increasing numbers of keyless watches now being made in this country, and the consequent adoption of the going barrel movement, deserves more attention than the subject has hitherto received. I think we ought not to drift into a change so great as the substitution of the going barrel for our good old servant the fuzee without at least having the respective merits of the two systems thoroughly discussed and properly understood. I will, therefore, notice a few of the points in which I think the going barrel watch inferior to the fusee, and our adoption of it a step in the wrong direction, bearing in mind that I am speaking of the English movement as it is at present made, or Swiss movements made on the same model, many of which are completed here and sold as English watches. Your correspondent, "Lemas," in your last month's *Journal* (suffering no doubt from some of the evils of our new manufactures), says, "English going barrel watches, either keyless or not, usually have a small barrel—so small that when a mainspring of sufficient force to obtain a moderately large vibration is put in, it will scarcely go over 4½ turns;" but this spring "of sufficient force" of 4½ turns would be quite long enough for a fusee watch, as three turns of the chain on the barrel would give 4½ on the fuzee (the usual number), and leave a turn and a half for adjustment and spare spring; indeed, fuzee watches are usually arranged for less turns of the spring than this in the barrel, but "Lemas" says we ought to have a spring much longer, and other competent authorities agree with him So then the first requisite of a good going barrel watch is to have a spring at least one-third longer than what I have shown is more than sufficient for a fuzee watch, and as the stop-work must be let into the top or bottom of the barrel the width of the spring is diminished by the thickness of the stop-work, which will be found nearly a third the width of the spring. It is, therefore, very easy to calculate the difference between the motive power of the going barrel and fuzee movements with equal height of pillars.

I am aware of the loss of power by the diminishing circumference of the fuzee and the friction of its pivots, but no practical English watchmaker will assert that this loss is comparative to what I have pointed out in its new rival; nor do I agree with "Lemas" that much can be gained by making the barrels larger; the fact is, the barrels are usually made as large as the movement will admit of; but with our notions of good watches requiring large and heavy balances, we try to keep the size of the balance to going barrel watches approximating to that of our old models, and the consequence is that springs too short must often be used, and this want of power is so much felt that the barrels are made so thin they dare not be gilt, and the first jobbing operation they undergo the chances are that they will be rendered useless. Again, the gathering piece of the stop-work—a very poor affair compared to the strong stop of a fuzee watch—is worked so close to the thin hole in the barrel where there is no room for an oil sink, that the oil is drawn away immediately. Even with the greatest care it is impossible for this movement to give anything like the satisfactory results obtained from good fuzee watches; nor will they last half the time.

It will surely not be contended that it is a sound principle of mechanics to waste so much power in so small a machine as a watch. But I may be asked, Why not adopt the Swiss movement, and by letting the barrel through the pillar plate get as much height of spring as we require? As I have stated, I am speaking of the movement as we make it at present, but should we ever find it necessary to imitate the Swiss in this matter, I think there would be grave objections to cramp the room for our escapement and balance by reversing the centre wheel, as well as to the ugly look it has. It would also be necessary to adopt some new and complicated winding work to the top plate; but the greatest objection to the going barrel still remains to be noticed. Nothing that can be called a main spring adjustment has ever yet been obtained from it, nor do its advocates pretend they can obtain it.

FUZEE.

Sir,—I do not wish to re-open the arguments, "Fusee *v.* Going barrel," but having read last month's *Horological Journal*, I am induced to write to you. Unless it is done to make the great mass of people, who are entirely ignorant of watches and watchmaking, believe that it is better to have a fusee and chain in a watch than not, I cannot see any reason why watches should be made with fusee; everything that reasonably can be expected from a watch can be made without fusee, and a watch without a chain has certainly the advantage of not getting out of order from fault in the chain, besides, if the maintaining power in a watch with fusee is out of order, the

watch actually goes backwards during winding. I have a watch here now without fusee, which has not been made as a showpiece, but is of the ordinary manufacture of Messrs. Mouline and Legrandroy, Geneva, it has been tried at the Observatory in Geneva, and I enclose you the rate of its going every day from the 21st of June, 1873, till the 1st of August, 1873; you will find the result is that the average gaining is one second and $\frac{8}{10}$ of a second, the average variation is $\frac{6}{10}$ of a second, and that it makes absolutely no difference between hanging and lying. The watch is a lever minute-repeating keyless, corresponding to an English seventeen size watch, jewelled in ten holes, breguet balance-spring, steel escapement, short lever, the balance large, and the vibrations 18,000 per hour.

CHRISTIAN LANGE.

99, Strand.

SIR,—I have often wondered how long a really good spring will wear, and although the question may not be of much value, still I think the subject an interesting one.

I know your columns are always open to anything bearing on the subject of Horology, and if the question stirs up the spring-makers and tends to improve the mainsprings of our day, it will not have been a waste of time. I send you herewith a mainspring that has been in constant wear 27 years. I also send a paper taken out of the case of the same watch that will show who put it in. Perhaps some of your readers, if you think it worth while, can give more information on the subject.

J. BLACKHURST.

SIR,—I was very pleased to see the remarks of your correspondent from the Vienna Exhibition respecting the "marvellous rates" of watches tried at the Swiss Observatories. I am sure the English manufacturer would not fear the result of testing his Fusee Watch with the best-going barrel work that Switzerland or any other country can produce. The result of rigid trial at our own Observatory, such as our chronometers undergo, would no doubt give the foreign watches a very different rate. I trust the matter will be taken up by some of our leading manufacturers.

TRIAL.

PROFESSOR JOSEPH HENRY, of the Smithsonian Institution, announced, on the 18th, the discovery of a new planet by Professor Watson, of the Ann Harbour, Michigan, Observatory. It was made last Sunday night, 23 hours 2 minutes right ascension, 2 degrees 40 minutes declination, small motion south, of the eleventh magnitude.

To Correspondents.

[MR. MAYER *desires us to state that his position as Editor of the* JOURNAL *terminated with the production of the August Number.*]

"S. L."—*All other things being equal you could scarcely expect an increase in the arc of vibration simply by substituting a Breguet spring for the ordinary volute..*

A more detailed description of the clock mentioned by your correspondent with a pendulum held by a figure and apparently detached from the works would, I believe, be read with interest by the trade in general.—ONUS PROBANDI.

R. P. WALTHAM.—*Yes. Denison's double three-legged gravity escapement has been successfully applied to regulators. We should not think the question of cost had anything to with the adoption of the zinc and steel pendulum for the Westminster clock. Probably Mr. Denison expected quite as good timekeeping from the zinc and steel as from the mercurial pendulum, and certainly the result has fulfilled his anticipation.*

AN APPRENTICE.—*There is no fee or charge whatever for exhibiting work at the Institute in the November Exhibition.*

"M. B."—*A simple and effectual mode of removing the dull appearance of the mercury in the glass jar of a pendulum, of which you complain, and bringing back its former lustre, is to fasten a piece of wash-leather to a stick and stir round the mercury with it, pressing the wash-leather against the inside of the jar. Unless the mercury contains grit or other foreign matter, following the above directions will give you satisfaction. If the mercury is mixed with dirt it may be necessary to empty it from the jar, and pour it back again through a wood or paper funnel having a very small outlet; in fact, only a pinhole, when the mercury will run through and the dirt remain.*

JAMES GOWAN.—*It is hardly correct to say the hall-mark for Scotland is totally distinct from that used in England. The hall-mark of the Goldsmiths' Company of Edinburgh consists of a castle, a thistle, a letter of the alphabet, and the Queen's head. The Goldsmiths' Company of Glasgow use a tree, with a fish, bird, and bell, a lion rampant, a letter of the alphabet, and the Queen's head. The Queen's head is the mark supplied by Government to all the assay offices in the United Kingdom, and the rest of the mark varies with every company. The castle in the Edinburgh mark, and the tree, fish, and bell in the Glasgow mark, constitute the arms of the respective cities, and the letter of the alphabet is changed every year to enable the companies to decide the year in which any particular piece of plate was marked.*

British Horological Institute.

DIARY of MEETINGS for OCT., 1873.

DAY.	DATE	TIME.	BUSINESS.
Thursday	2	8.0	Technical Class.
Monday	6	8.0	Ditto.
Tuesday	7	8.30	Council.
Thursday	9	8.0	Technical Class.
Monday	13	8.0	Ditto.
Tuesday	14	2.30	Visit to Westminster Clock.
Tuesday	14	7.30	Journal Committee.
Thursday	16	8.0	Technical Class.
Monday	20	8.0	Ditto.
Tuesday	21	8.30	Exhibition Committee.
Thursday	23	8.0	Technical Class.
Monday	29	8.0	Ditto.
Thursday	30	8.0	Ditto.

MEAN TIME OF THE SUN'S SEMIDIAMETER PASSING THE MERIDIAN OF GREENWICH, AND EQUATION OF TIME TABLE.—October, 1873.

Day of the Month.	Mean time of the Sun's Semidiameter passing the Meridian.		Equation of Time *to be subtracted from* Apparent Time.	
	M.	S.	M.	S.
1	1	4·2	10	24·2
2	1	4·2	10	43·1
3	1	4·3	11	1·7
4	1	4·3	11	20·0
5	1	4·4	11	37·9
6	1	4·4	11	55·5
7	1	4·5	12	12·7
8	1	4·6	12	29·4
9	1	4·6	12	45·7
10	1	3·7	13	1·6
11	1	3·8	13	16·9
12	1	4·9	13	31·7
13	1	4·9	13	46·0
14	1	5·0	13	59·8
15	1	5·1	14	13·0
16	1	5·2	14	25·6
17	1	5·3	14	37·6
18	1	5·3	14	49·0
19	1	5·4	14	59·8
20	1	5·5	15	10·0
21	1	5·6	15	19·5
22	1	5·7	15	28·3
23	1	5·8	15	36·4
24	1	5·9	15	43·9
25	1	6·0	15	50·6
26	1	6·1	15	56·7
27	1	6·3	16	2·0
28	1	6·4	16	6·6
29	1	6·5	16	10·4
30	1	6·6	16	13·5
31	*1*	6·7	16	15·9

NORTH POLAR DISTANCE AND DECLINATION OF CERTAIN STARS, AND TIMES AT WHICH THEY ARE ON THE MERIDIAN OF GREENWICH.—October, 1873.

Star's Name and Magnitude.	Day of Month	N. P. D. / Declination, At Meridian Passage	Sidereal Time / Mean Time At Meridian Passage.
		° ′ ″	H. M. S.
β Ceti	3	108 40 44·8 s 18 40 44·8	0 37 15·74 11 46 17·8
	13	108 40 45·8 s 18 40 45·8	0 37 15·8 11 6 58·7
Mag. 2.	23	108 40 47.1 s 18 40 47·1	0 37 15·8 10 27 39·7
o Ceti	8	90 50 1·9 s 8 50 1·9	1 17 43·36 11 7 9·0
	18	98 50 2·5 s 8 50 2·5	1 17 43·4 10 27 50·0
Mag. 3.	28	98 50 3·3 s 8 50 3·3	1 17 43·5 9 48 31·0
α Andromedæ.	3	61 36 20·2 N 28 23 39·8	0 1 52·3 11 11 0·1
	13	61 36 18·5 N 28 23 41·5	0 1 52·3 10 31 41·0
Mag. 2.	23	61 36 17·0 N 28 23 43·0	0 1 52·2 9 52 21·9
α Pegasi (Markab)	8	75 28 21·3 N 14 31 38·7	22 58 28·6 9 48 7·3
	18	75 28 20·6 N 14 31 39·4	22 58 28·6 9 8 48·1
Mag. 2.	28	75 28 20·1 N 14 31 39·9	22 58 28·5 8 29 29·0
ζ Cygni	3	60 17 18·0 N 29 42 42·0	21 7 33·8 8 17 10·2
	13	60 17 17·0 N 29 42 43·0	21 7 33·6 7 37 50·9
Mag. 3.	23	60 17 16·4 N 29 42 43·6	21 7 33·4 6 58 31·6
α² Capricorni	8	102 56 9·0 s 12 56 9·0	20 11 2·5 7 1 8·6
	18	102 56 9·4 s 12 56 9·4	20 11 2·3 6 21 49·3
Mag. 3·5.	28	102 56 9·8 s 12 56 9·8	20 11 2·2 5 42 30·1

THE COMPULSORY REGISTRATION OF VALUABLES.

HOWEVER disproportionate the charge for registering and the benefit conferred by the registration of letters, no complaint was heard so long as the registration was optional. It was simply a matter of agreement. The postal authorities said, in effect, "If you pay us an extra fee we will use extra vigilance to secure your letter against loss, at the same time should it be lost in spite of our care you must not expect us to reimburse you." But the moment that registration upon these terms is made compulsory a grave anomaly is introduced such as would not be tolerated in any monopolist corporation unconnected with Government; and although the official circular recently issued is not very clearly expressed, we must assume that this compulsory enactment is to be enforced. The sole argument adduced by the postal authorities is that letters containing valuable articles, if left unregistered, offer a temptation to those engaged in the transmission of the letters, to which they ought not to be subjected. Surely those engaged in the Post Office are not less honest than the majority of their fellow men. Is it not possible that the low rate of wages given to the letter-carriers and others handling the letters surrounds them with an unnatural temptation? However, admitting that there is a just cause for demanding an extra fee on account of the extra supervision required over letters known to contain valuable articles, the amount of the fee at present demanded is altogether excessive. Actually four times as much as pays the carriage of an ordinary letter! It is a fetter upon the transmission of small articles of jewellery, &c., that will be severely felt by many members of our trade, besides the annoyance caused by the uncertainty as to whether any particular article comes within the category of "valuable articles." But the amount of the tax seems still more out of proportion to the benefit conferred, when we consider that the Post Office does not propose to give us security for our money. What would be thought of a railway company who demanded five times the usual carriage on account of the extra value of the articles transmitted, and then coolly refused to be responsible in case of loss? The position of the posta authorities is clearly untenable.

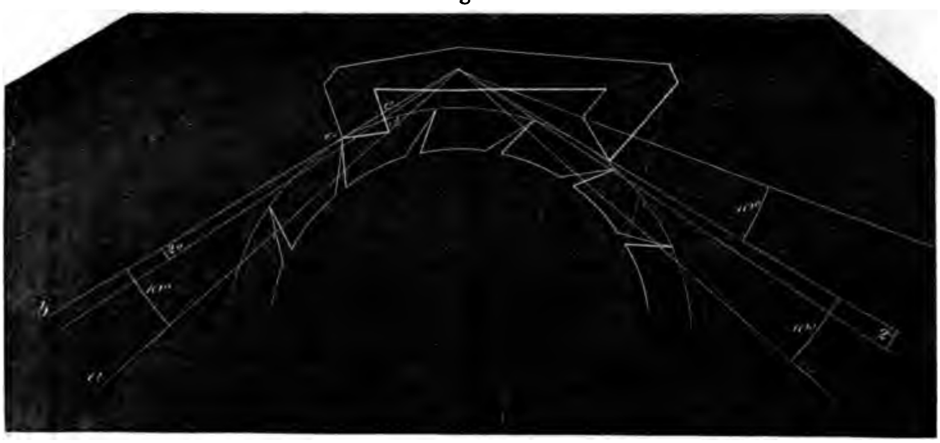
The North of England Horological Society have memorialised the members for Leith and Gloucester (Mr. Macfie and Mr. Tait) to use their influence with the postal authorities so that the registration fee should bear a ratio to the value of the article transmitted, and that the Post Office authorities should hold themselves liable in case of loss. By the courtesy of Mr. Reid, the president, we are favoured with a copy of the memorial, which, after thanking the members for past services, and pointing out the inconsistencies of the present system of registration, says—"If the postal authorities will make the regulation of letters an assurance against loss, we have no objection to insure according to the value sent, say small sums of money or valuables of 5s. and under 10s., one penny; 10s. and under 20s., twopence; 20s. and under 40s., threepence; and so on according to value stated. We feel confident that if this plan of assurance was adopted by the Post Office, it would not only be a source of increased revenue, but there would be no need for compulsion, as everybody having valuables to send would only be too glad to avail themselves of the privilege thus afforded them."

The proposition of the North of England Horological Society is not original; but it is reasonable and workable, and, unless the postal authorities remodel their conditions of registration in the interim, no doubt shadows the scheme that will be pressed upon the notice of the Government in the next Session of Parliament.

MEASURING TOOLS FOR LEVER ESCAPEMENT.

Sometime ago I was much amused by hearing two escapement makers discussing the angle which they made their escapements. One used pallets of 10°, while the other preferred them of 12°. The former made the roller and lever of such proportions as to produce 30° of impulse at the balance; while the latter made them to produce 35°. How they arrived at this conclusion I don't know, for I have since ascertained that in making an escapement they turn a piece of steel for the roller to the size of a hole in a piece of brass used as a gauge, which also has holes of various sizes for different sized escapements. A hole is then made for the ruby pin near the edge, a piece of lever steel is then taken and a hole made in it for the pallet staff, and from that hole a place is marked for the guard pin, from a gauge made of brass, on which the several distances are marked for levers of various sizes, and in pitching the escapement the roller depth is determined by the guard pin just freeing the bottom of the roller crescent. According as the crescent is deep or shallow, so the depth of the roller is; they then tell you that an escapement made in this manner has 30° or 35° of impulse at the balance, not knowing what the lifting angles of the pallets are, although they believe them to be 10° or 12°, but of which they should be quite sure before commencing to make an escapement. They both agreed that a double roller escapement was far superior to one with a single roller, although they did not appear to know how the superiority of result was produced, as they used precisely the same proportions, but why they used these proportions they could give no reason, unless it were that those before them had used the same, thus showing how limited was their theoretical knowledge of the escapement. And this leads me to the conclusion that sufficient attention is not given by escapement makers to the lifting angles of the pallets, especially as on them depend the proportions of the roller and lever. Perhaps it may be due to the want of an instrument that will accurately measure the pallet angles. If such is the case, I think the want might be supplied, as many in the trade, when they come to consider the necessity for such an instrument, would at once set to work to supply the want, and not remain content with the system bequeathed to them by former generations. I am not so presumptious as to dictate to the trade, as I have no doubt there are many makers who, by a plan of their own, obtain an accurate measurement, but I still contend it would be a great boon to the trade to have a standard tool for their guidance. It is with that view I have made these observations, which, if you think will interest your readers, I will further illustrate by describing the method I adopt to ensure the correct measurement of an escapement.

Fig. 1.



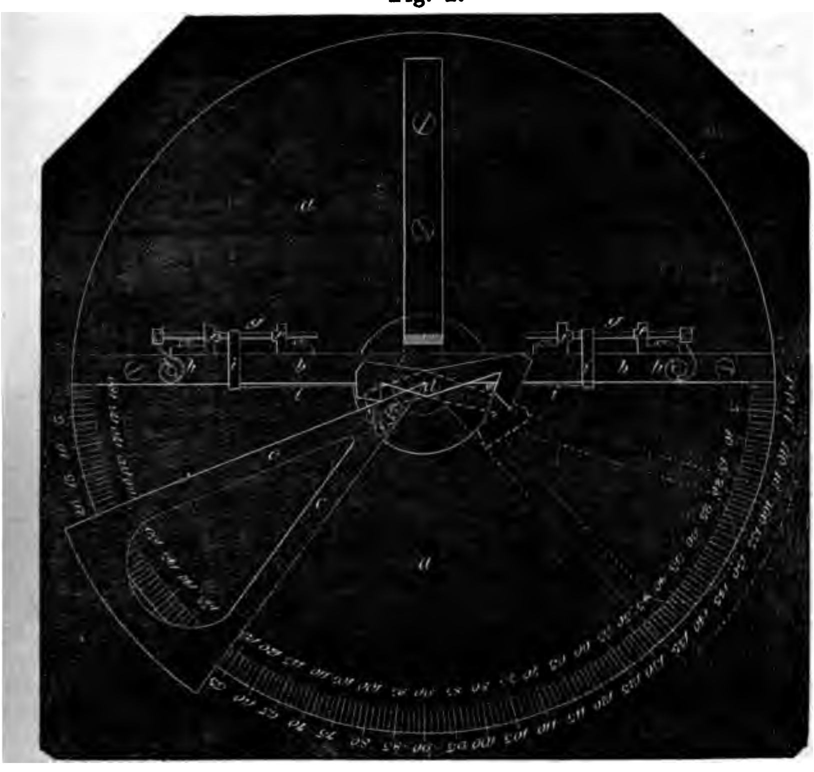
Mr. Grossmann, in his prize essay on the lever escapement, informs us that the lines *a* and *b* (Fig. 1) represent the lifting angles of the pallet, that is to say, the wheel in passing over the pallet plane moves the pallets the number of degrees those lines embrace. Now, with all due respect to so high an authority, I submit that is not the case, because the wheel starting from the corner *c* of the receiving pallet passes over the plane and is discharged at point *d*, which is 2° less than that embraced by lines *a* and *b*, as shown in Fig. 1, on reference to which it will be seen that the line *b* forms a tangent to the wheel. therefore the wheel cannot move the pallets to point *e*.

I will now, in the first place, describe a

have made for measuring correctly the angles of the pallets. In Fig. 2, *a a* ents a plate made of German silver rted on three feet). *b b* a lever made pered steel and firmly fixed to plate *a* the centre. *c c* is a lever thicker than ', and the sides of which are in a straight centre *d* (round which it revolves 150°), ich the pallets are held by a centre acts spring-tight through upright *e*. neasure the receiving pallet, one side of er *c c* is brought against the discharging and forces the pallet round until the ng corner is brought level with the in- ce of lever *b*, which is determined by apement fixed to one side of lever *b*, hich is constructed in the following r: *f f* represents two uprights screwed lever *b* having holes through them l to the lever, through which passes a) turned and carefully fitted, having at one end a spring (*h*), forcing it towards the centre; to the middle is fixed a spring (*i*), which laps over to the inside face of lever *b* and presses close thereon; the end of spring (*i*) is forced against the locking plane of the pallet by spring *h*, so that when lever *c c* forces the pallets round so as to bring the locking corner level with the inside face of lever *b*, the spring *i* escapes down the plane and the lifting angle of the pallet is registered on the outer circle of the plate (which is engraved to show degrees) less 2°.*

To measure the discharging pallet an escapement similarly constructed is fixed on the other side of lever *b*, with this difference, that the rod *g* instead of being forced towards the centre by spring *h* is forced from it, and therefore the point of spring *i* is forced against the locking plane, so that when the lever *c c* is brought against the discharging corner and forces the pallets round until the receiving

Fig. 2.



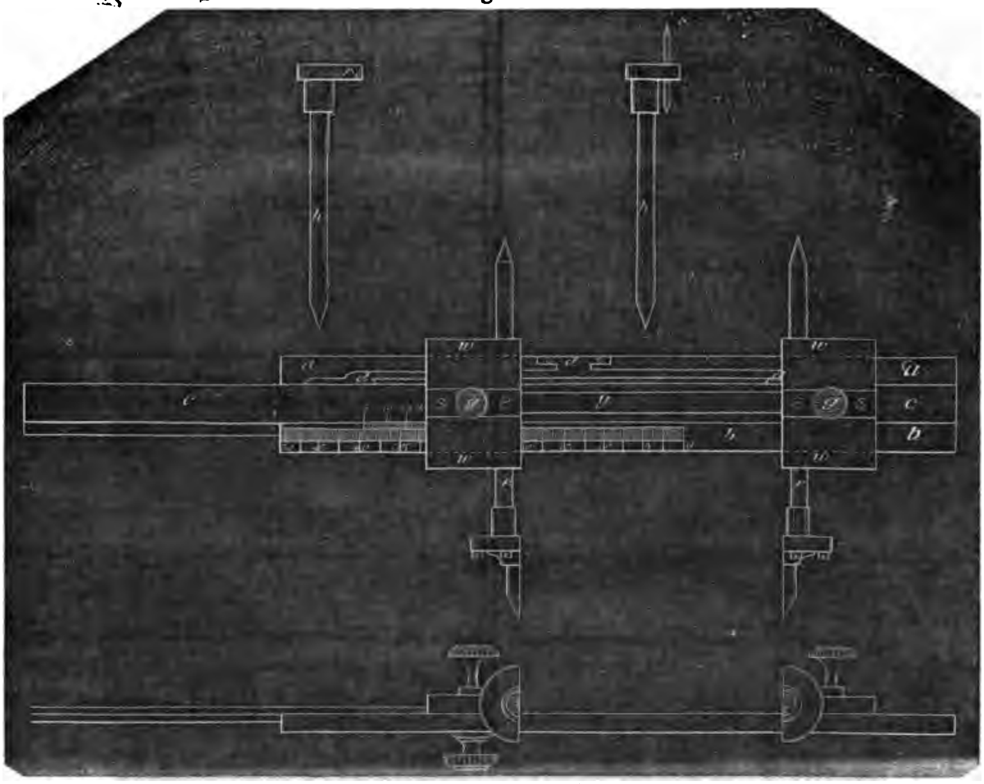
is level with lever *b*, the spring *i* es- lown the plane and the lifting angle of scharging pallet is registered on the ircle of the plate less 2°.

w, in the second place, will describe a I have made for measuring correctly ing lengths of the lever and roller, and ther parts of watch work. It is represented by Fig. 3, is made of German silver, and is on the principle of the sliding gauge, and is engraved to measure the 0·001 of an inch. The body *a a* is 3½ inches long by ⅝ wide, and on one side is screwed an edge

* It will of course be understood that this allowance of 2° is assuming the 'scape wheel to have the usual number of 15 teeth.

(*b b*) dovetailed on the inner side, under which the slide *c c* (which is 4¼ long by ¼ wide) is kept by spring *d d d*, thereby acting spring tight. At right angles and near the end of body *a a* is a jaw (*p*) firmly screwed on, through one side is a hole carefully and smoothly bored, through which centre *f* is carried at right angles to the body. In the centre of this jaw is a bar of steel with a screw at each end; one holds a plug acting through a hole on centre *f*, for the purpose of fixing it in any position required by the action of screw *g* pressing on the bar, and so forcing the plug on centre *f*, and thus firmly holding it, while the other is used as a regulating screw, and keeps the bar parallel to the jaw. Secured firmly on the slide *c c* is another jaw similarly constructed, and which also carries a centre *f* at right angles to the slide, so that these two centres act parallel to each other. When the slide *c c* is moved backward or forward, so the centres recede or approach, and when one centre is moved as close to the other as it will go they are 0·077 of an inch apart, the diameter of each being 0·60 of an inch, gives about 0·008 of an inch from the inner side of the jaws to the holes through which the centres pass. It may be said that this is too weak to be sound, that it might give a little at the ends and so impair the accuracy

Fig. 3.



of the gauge; but this is guarded against by a thick bar of tempered steel (*w*) screwed on at each end of the jaw, and through which the centres tightly pass, thus giving great strength to the holes. In measuring by these centres the distance of centres must be allowed for. For instance, if it is required to measure the inner diameter of a barrel, one centre is placed in the hole while the other is brought to bear on the inner edge; and, for example, say it is found by the scale to measure 0·3 of an inch, which is its semi diameter, therefore its diameter will be 0·6 of an inch by the scale, and allowing for the distance of centres, which is 0·077, its actual diameter will be 0·523 of an inch. To measure the outer diameter, which can be done by laying the barrel on the body of the gauge and pushing the slide up against it, so as to fix it between the jaws, which will at once give the correct measurement, or by placing one centre in the hole and bringing the other to the outer edge the semi-diameter is obtained, as for example, say 0·320 of an inch, its diameter therefore by the scale, will be 0·640; and allowing for distance of centres, its correct measurement will be 0·563 of an inch. To measure parts less than 0·77 of an inch, the other ends of the centres can be used on which

are fixed heads; their forms, as will be seen by the engraving, are semi circles, so that when closed by the slide they form one centre; or by removing one of these centres and putting centre *h* in its place, which has an arm at one end in which a scoring centre is fixed, the point of which (when the gauge is closed) coincides with the other centre. The use of this centre is that any measurement can be made without allowing for the distance of centres, thus obviating a second calculation.

I may here mention that the slide *c c* is pierced by a notch *y* two inches long, which coincides with one in the body *a a*, for the purpose of allowing pinions to pass through while measuring the diameters of their wheels, which is done by placing the wheel between the jaws and fixing it by slide *c c*, thus giving its correct measurement.

To measure the acting diameter of a roller, centre *k* is used, on one end of which is fixed an arm with a small hole in the end, and when the gauge is closed this hole coincides with the point of the other centre, the hole in this arm is then placed on the balance staff lower pivot, and the slide *c c* is moved so as to bring the other centre across the ruby pin (the centre of which can be determined by smearing the end with wax), its acting diameter is then registered on the scale to the 0·001 of an inch.

To measure the acting length of the lever the distance between the balance staff hole and the pallet staff hole is measured, from which is deducted the acting length of roller, the remainder being the length of the lever—say, for example, the distance between the holes is found by the gauge to be 0·2 of an inch and the acting diameter of roller is 0·05, then $0·2 - 0·05 = 0·15$, which is the acting length of the lever; and by measuring the pallets as above described, and which, say, for example, are found to be 8°, the impulse at the balance would be $\frac{0·15 \times 8}{·05} = 24°$, and with pallets of 10° would be $\frac{0·15 \times 10}{·05} = 30°$, and with pallets of 12° would be $\frac{0·15 \times 12}{·05} = 36°$. And again, if the distance of the holes be 0·22, and the acting diameter of the roller is ·055, the acting length of the lever would be $0·22 - ·055 = 0·165$, and with pallets of 8° the impulse at the balance would be $\frac{0·165 \times 10}{·055} = 24°$, and with pallets of 10° would be $\frac{0·165 \times 10}{·055} = 30°$, and with pallets of 12° would be $\frac{0·165 \times 12}{·55} = 36°$.

This guage may be used advantageously where a new lever and roller are required to be made. The distance between the balance staff and pallet staff holes should be measured, and which, for example, say, is 0·212 (about the distance they are apart in a 12 size watch), which must be divided into two parts: one part for the acting length of lever, and the other for the acting diameter of roller. The relative proportions of these parts must be (with pallets of 8° and an impulse at the balance of 30°) as 8 is to 30. Then

Let $x =$ 1st part
$0·212 - x =$ 2nd part
$: x : 0·212 - x :: 8 : 30$
$30x = 1·696 - 8x$
$38x = 1·196$

Therefore $x = 0·044$ which is acting diameter of roller, and $0·212 - 0·044 = 0·168$ which is the acting length of lever, and for an impulse at the balance of 35° the proportion will stand thus

$$: x : 0·212 - x :: 8 : 35$$

which gives 0·039 for length of roller, and 0·173 for length of lever.

It will be seen by the foregoing examples how important a part the lifting angles of the pallets play, and how necessary it is to know them before commencing to make an escapement, as a variation of 1° in their amount is multiplied two, three, or four fold at the balance.

I believe there are many escapement makers who give this but little attention. They act under the impression that the pallets are a certain angle, and rest satisfied, and make lever and roller the same proportions in all cases, which accounts for many errors found in escapements, some will rest, others will have too much run on the pallets, while some will have too little, and a variety of other faults with which a good examiner is well acquainted.

I attribute this to the want of proper tools for correctly measuring the different parts.

Allow me to suggest in conclusion the great advantage that would accrue to the trade from standard gauges, the inconvenience arising from the want of such gauges is so continually felt by all branches of the trade, that the suggestion carries its own argument.

Were the Council of the Horological Institute not only to use its powerful advocacy in favor of such an arrangement, but take the initiative by causing such gauges to be placed before the trade, I believe, they would be readily and favourably accepted with advantageous results.

I would further suggest, that a means to this end would be by unlimited competition in the invention of such gauges, and for the best of which a small prize might be awarded by the Council.

Should the few remarks I have made attain the dignity of criticism, I trust your correspondents will favour us with their views in clear and concise language, so that some practical result may follow.

R. B.

THE WESTMINSTER CLOCK.

The members of the Horological Institute had the benefit of a second visit to the king of clocks in Westminster tower on the 14th October, and a large number of members both from London and the country availed themselves of the opportunity.

The day was beautifully fine and clear, a marked contrast to the two preceding days, and rendered the visit one to be remembered, not only from the interest attaching to the inspection of the clock, but from the delightful view that was obtained from the belfry and from the lantern above; a view that for its real beauty, its inherent interest, and the grand and varied character of its surroundings can scarcely have a parallel.

Just below wound the majestic river, one of the principal sources of London's greatness, sparkling and glancing in the light, with the rapid steamers flitting to and fro. The splendid hospital recently erected on the southern bank, with its glittering windows reflected in the passing tide. The grand boulevard of the Embankment, which has so vastly improved the north bank of the river that one longs to see it paired on the other side, leading away eastward. The huge bulk of St. Paul's Cathedral, dwarfed in the distance but clear as a gem, charming the eye by its pure proportions and graceful contour. The hills on which the Crystal Palace glows, stretching along towards the south-east in a delicate haze. More northwards the green swards and leafy trees of St. James's-park, with all the noble buildings that surround it, showed clear and distinct; while more westward a cloud of haze and smoke drooped like a veil over the scene, permitting, here and there, a glance as tower and spire pierced through its half concealment. Nearer us lay the ancient Abbey, in calm grandeur, the casket of the nation's history; and just beneath us, in isometric plan, were the Houses of Parliament and the great and noble hall which forms their vestibule, round the gate of which were already clustered the nucleus of a gaping crowd, awaiting the hour of four to see and cheer that huge gross bulk, the cynosure of a trial, that, whichever way it terminates, if it ever does, is a disgrace to our legal system.

But our business is not with the outside, though the glorious day has tempted us to the prospect; our duty and the real attraction of our visit is the inspection of the clock whose pulses throb so softly yet so healthily within, and whose far-reaching voice tells of the lapse of time, with such unerring truth that while it warns us of its rapid pace it cheers us in the hope of future hours of peace and pleasure.

The place where the present clock tower stands has been for more than 500 years the site of a great public clock. About the year 1365 there was a stone clock tower erected here by order of Edward III. The clock, which it contained, struck the hours on a great bell heard in the courts held in the hall, and even in the City of London itself in calm weather. There were also other large bells in the tower, rung on triumphal occasions, coronations, and other great events. In the reign of Henry VI., a clockmaker named Thomas received a salary of 13s. 4d. a year to superintend the clock, and from the accounts of the prices he was paid for certain of its repairs, &c., it is clear that its cost was but a trifle compared with that of the present great one, on which, from a statement of Mr. Cowper in 1860, it appeared that £20,300 had been expended and a further sum of £1,750 was in course of disbursement. This enormous cost does not, however, represent the actual cost of the mere clock, which was £4,080, being Mr. Dent's outlay, with ten per cent. profit, but was incurred in the thousand and one lets and hindrances, suggestions and oppositions, doubts and difficulties, experiments and failures, inevitable in producing any great national work in this country. The first notice of the intended clock was in a communication, dated 29th March, 1844, from the architect of the Houses of Parliament to Mr. Vulliamy for specification and plan for one to strike the hours on a bell of from eight to ten tons, chime quarters on eight bells, and show the time on four dials of 30 ft. each in diameter. The present clock was ultimately set going in 1859, after waiting four years for the tower and bells, but not fully completed till 1860.

To go over the whole details of the correspondence and of the plans and specifications that were made would be of no use for our present purpose and tedious in the extreme. Suffice it to say, that ultimately Mr. Dent was asked to undertake the task, which he did. In 1852, however, he died, and as his successor, Mr. F. Dent, had more taste for the production of delicate chronometers than such heavy work as this great clock, Mr. Denison, Q.C., undertook to design and superintend its construction, and notwithstanding opposition and discouragement, at length produced the finished marvel of horology.

The rate of the clock has been stated by the Astronomer Royal to be certain to much less than a second a week. Mr. Ellis, of the Royal Observatory, also says there is no clock in Greenwich which keeps time so well as Mr. Denison's clock in the Houses of Parliament.

Another account gives its rate as being one second in ten days; and it is reported as having been only three seconds wrong on two per cent. of the days of observation.

The frame, which carries the works of the clock, is 15 ft. 6 in. long, and 4 ft. 7 in. wide. The going part takes up about two feet of this width. The back of the frame is 2 ft. 5 in. from the west wall of the room, which is 28 ft. by 18 ft., and the clock lies on the north and south walls of the weight shaft, which is 174 ft. deep. The floor of the room is 2½ ft. below the top of two iron plates, which cover the walls, and, spreading out behind, are built into the wall to prevent any endway motion of the clock frame, which is bolted to them. The pendulum cock is a large piece of iron framework cast in one piece and built into the wall independently of the clock frame. The pendulum chamber is of sheet iron in the weight shaft to keep off the wind, and can be entered by means of a trapdoor and ladder. To alter the clock by any less quantity than four seconds or two beats of the pendulum, a collar is fixed on the rod 4 ft. 10 in. from the top, to carry regulating weights: 1½ oz. placed there accelerates the pendulum one second a day. There is also a large weight of about 6 lbs. fitting round the rod so that it can be removed. If the clock is too fast this being removed will retard the rate one second in about fifteen minutes; or it may be set forward by laying on a similar weight. If necessary, it can be set forward four seconds by lifting the pallets and letting it trip one beat, and then reduce it by taking off the weight lying on the pendulum.

The weight of the pendulum is 685 lbs. altogether. Its total length 14 ft. 5 in. The zinc compensation tube is 10 ft. 5 in., and is made of three tubes, one within another, and then drawn together. It is about half an inch thick. The centre of gravity of the bob is about 8 in. below the centre of oscillation, owing to the weight of the compensating tubes. The pendulum spring is $\frac{1}{30}$ inch thick, 3 in. wide, and 5 in. long between the chops. It can be adjusted by nuts on each end of the upper pin to the centre between the pallet arbors. Six feet are left between the cock and the floor to enable a man to stand there and look square at the action of the escapement.

This is the double three-legged gravity escapement, one of the simplest and most complete forms of escapement yet devised for completely isolating the pendulum from the varying pressure of the train. In large clocks, and especially so large a one as this, the mass of weight that has to be moved at each beat of the pendulum is so great as to require more force than would be safe to have act directly on the escapement; and if, by mechanical arrangements, it be modified within a proper amount, there is still the variation of force resulting from thickening of oil, dirt, or other causes that would interfere with the equable application of driving force to the pendulum. In the double three-legged gravity escapement these things are all removed. The work of the train is simply to raise alternately on either side of the pendulum-rod the pallets which drive the pendulum. These pallets lie on different parallel planes, and swing on pivots near the top of the pendulum. At their lower ends they have each a pin at right angles to the plane in which they work, by which the pressure of their weight is allowed at the proper time to bear on the pendulum-rod. The escapement consists of two locking wheels, each with three legs like the Manx crest, they are fixed one behind the other, wide enough apart for the pallets to lie between them, and there is one set of lifting pins. These pins alternately lift the pallets into a position in which one of the legs of the locking wheel engages a stop on it. On the swinging of the pendulum to that side it touches the pin projecting from the pallet, and, lifting it a little, disengages the leg, which falls forward, till a leg of the other locking wheel engages the stop of the other pallet, which has been lifted to the opposite side by the lifting pin, and is kept there by the leg as before. That pallet which had been first lifted now rests with its weight pressing on the pendulum rod by means of its pin, and, having first checked its swing a little, assists it on its return, supplying just the needful force to keep it going. On its swing to the other side the same process is repeated, and so on. The pressure of these arms is equal in amount to the fall of one ounce from a height of $\frac{6}{10}$ inch; that of the 'scape wheel teeth or "legs" on the stops of the pallets is 4 oz.; in an ordinary dead beat escapement it would have been above 4 lbs., and in some forms of escapement as originally proposed for this clock it would have struck the pallets a blow each time of about 7 lbs., which would have been a resisting force on the pendulum throughout its vibrations. When it is considered that a clock is simply a machine to count the vibrations of a pendulum, how evident is it that the less it has any effect of its own on the pendulum the better for its time-keeping properties. A fly of about 11 in. by 2 in. in each vane is set on the 'scape wheel arbor with a silent ratchet allowing it to run forwards only, to check the blow of the legs on the stop pins.

As a maintaining power while winding a very simple expedient is adopted. From the force to be overcome an auxiliary pinion is required which engages a wheel on the end of the barrel next to the great wheel. The arbor of this pinion reaches right across the clock frame, and it is put in gear in the usual way by sliding it through the bushes in which it works and which are made loose fitting. The arbor at the back is at the end of a loose bar which hangs obliquely from the back pivot of the barrel, and when the pinion is in gear, the turning of the handle would cause it to run over the wheel on the barrel like the old contrivance of the sun and planet wheel. The hanging bar has however a spring click on it, which engages a set of ratchet teeth on the back face of the great wheel, and which, while it lets them slip under when the clock is not winding, fixes in one directly the pressure is put on to wind, and becomes the fulcrum for the bush at that end, thus transferring the force from the barrel to the great wheel and keeping it going still in the same direction. As the clock takes twenty minutes to wind, the great wheel during that time would pass through sufficient distance to make the obliquity of the winding arbor too great. This is prevented by an arm at right angles to the winding arbor and fixed to it, which, when about ten minutes have passed, catches against a pin on the frame and stops the winding. The man then lets go the handle, the barrel takes up the pressure on the great wheel, and the pinion drops back to its original position ready for a start of ten minutes more.

The dials are 22½ ft. in diameter, nearly 400 square feet in area, and consist of a cast iron framework giving the divisions and figures, and filled in with opalescent glass $\frac{1}{16}$ inch thick. The minute spaces are a foot square. The figures 2 ft. long. The minute hands are thin copper tubes of a section enclosed by two arcs of circles and strengthened by diaphragms at certain parts. These are set on gun metal solid stalks which form also counter poises, assisted by cast iron ones in the clock room. The tubular parts of the hands weigh each 28 lbs., and each gun metal stalk nearly four times as much; but its weight being near the centre is of less account. The total weight of each hand with counterpoises is less than 2 cwt, whereas the original minute hands devised by the architect weighed each 6 cwt. 1 qr.

The wheels that strike the quarters have circular cams with hard steel faces, constructed to give the least possible friction and the freest drop for the lever. The pull is made upon wire ropes, and the direction changed by cranks in an intermediate chamber between the clock room and belfrey. The hammers are nearly $\frac{1}{40}$ the weight of the bells. The fourth bell has two, because in one of the quarters the blow is repeated too quickly for the hammer to fall and be lifted again. The great striking wheel has ten cams 2½ in. wide upon it. The cast iron head of the hammer weighs near 7 cwt., and is lifted 13 inches from the bell. Each striking weight is nearly a ton and a half, which is about half what would have been required if pins had been used instead of cams.

The condition of striking was fixed that the first blow of the hour should be within a second of the true time. To meet this a special arrangement was required. An ordinary discharging lever is lifted by the snail on the hour arbor. It carries at its end the first stop of an arm on the third wheel of the striking train, which rests there at the last stroke of each hour. The second stop is on a short independent lever. Underneath lies another lever set on pivots on the crossbar of the great frame, and having its heavy end lifted and dropped every 15 minutes by a snail on that wheel of the escapement. Every time it drops it gives a blow on the second lever, which lifts it, but with no result until at the warning it has the arm of the striking train resting on it. At the fifty-eighth second, or one beat before striking, it is let off, and the train has then time to get far enough forward to let the hammer fall within the proper time specified. The quarters are rarely more than two seconds from the right time at the first stroke, except the fourth, which is let off 20 seconds before the hour, so as to be finished before the hour should strike.

The striking parts only go four days, and are therefore wound twice a week. Had they been made to go as long as the time train, no man could have wound them in a day, whereas now it can be done in a short day's work. Stops are provided which prevent him from winding when the quarters or hours are striking.

The clock reports its time to Greenwich twice each day by electricity, and its rate is checked and recorded, and any error telegraphed and corrected, by the means beforementioned. The great bell sounds the Note E. Its diameter is 9 ft., its thickness 8¾ in., and its weight 15 tons 11 cwt. The quarter bells are respectively: Note B, 78 cwt.; E, 33½ cwt.; F sharp, 26 cwt.; G sharp, 21 cwt.

By the courtesy of Messrs. E. Dent and Co. (to whom, on the motion of Mr. Glasgow, an unanimous vote of thanks was passed), Mr. Camman was present to explain the details of the clock, and to him we are indebted for much

r information. Owing to the very nu-ıs throng of visitors and the smallness of lock-room, it was difficult to get near ;h to investigate it thoroughly; but by ag till many had gone we had the oppor-y of making a closer acquaintance than we one on a former visit, earlier in the year, ıemorable among the annals of our expe-›. The moral to be drawn from the whole at in all great works, simplicity of con-:ion should ever accompany accuracy of and workmanship; and that patience and nination overcome in time what appear insurmountable obstacles.

Height of Pinions.

VE frequently been asked by watch-rs how to obtain the height of pinions, specially in very small scape pinions eneva work. The following modes will und efficient: If the operator is pos-l of a Douzieme gauge, and supposing ıeight of a pinion is wanted, gauge the le of the plates (or if jewelled with end s, of the distance over the outsides of pieces), then with the same tool ıre the thickness of each of the plates; :t the sum of the two plates from the height over the plates, and the remain-rill be the height of the pinion between houlders, after allowing a little for end . If, however, such a gauge is not at when the height between the shoulders small scape pinion is required; wet :ly with oil both jewellings and their andings, after which, warm a small piece :llac so that it fills up the space between ›wel holes, the shellac will, when cooled, sent the exact height required.

Loose Fitting Dial Feet.

ill often be found, in fact it very gen-r happens, that the dial feet of watches ery shaky in the plate holes, sometimes ıch that the pipe of the seconds-hand is ınger of being touched. A clean and way of correcting this fault is to drill small holes through the diameter of the vhere they should fit the plate, and then ; brass or copper pins, allowing them to ct beyond the diameter of the feet just ;h to fill up the space between the feet he holes in the plate. The same treat-may be applied with advantage to pillars do not fit the upper plate in full plate ıes.

W. G. SCHOOF.

The Plate Licence.

A CASE has occurred at the Clerkenwell Police Court, since we last went to press, in its results fully justifying our anticipation that the action taken against the retail jewellers by the Commissioners of Inland Revenue was based upon a wrong interpretation of the Plate Licencing Act.

Mr. Thomas Pickford, of 178, Upper-street, Islington, jeweller, was summoned before Mr. Barker by the Commissioners of Inland Revenue, for having unlawfully sold a gold chain, weighing 2 oz. or 12 dwts., on the 11th of August, he only holding a licence to deal in gold plate under 2 oz.

The representative of the Board stated that the prosecution was based upon the interpretation of the 5th section of the Act, that goods sold for gold or silver were to be deemed to be so.

Mr. Powell, on behalf of the Inland Revenue Office, appeared for the prosecution, and called an officer who had purchased the chain, to prove that the chain was over 2 oz.

Mr. John Layton, who appeared for the defendant, said that his client contended that he was permitted by the 30th and 31st Vict., cap. 90, sec. 1, to sell any articles which contained less than 2 oz. of gold by virtue of his licence, and that the Act meant pure gold, and not a mixture of gold and base metals. He referred the magistrate to a recent decision in a similar case, which was heard before the Louth magistrates in August last, and called Mr. Wells, from Messrs. Buller and Hutchinson, of Bartlett's-buildings, the makers of the chain, and Mr. Marshman, of Clerkenwell-green, a working jeweller, to prove that there was not 2 oz. of gold in the chain. Both witnesses deposed to its being an 18-carat chain, and that it contained 1 oz. 19 dwt. of *pure gold*, and 13 dwt. of alloy, not gold, and that the price charged (£14) was fair and reasonable.

The magistrate said that he was of opinion that the defendant had not infringed his licence, and dismissed the summons.

The Turners' Competition.

THE prizes offered by the Turners' Company brought forth some excellent specimens of turning in stone and ivory, of which we were favoured with a view by the courtesy of Professor Tennant, the Master of the Company. It is a matter for regret that not one worker in any of the precious stones was a competitor. The prizes—this year supplemented by a gift of £25 from Lady Burdett-Coutts — were distributed at the Mansion House by the Lord Mayor in the presence of a fashionable company, on Monday, the 13th October.

THE DIAMOND AND OTHER PRECIOUS STONES.

By M. BABINET, of the Institute of France.

(From the "Smithsonian Report" for 1870.)

SECTION II.

If no more large diamonds should ever be found, it will be on account of their extreme scarceness, which recalls a saying of Tacitus with regard to the pearls of England: "It is rather nature that fails in their production than the avidity of man in their discovery." Hitherto Borneo has contributed no diamond of any considerable size. It is true, however, that the almost impenetrable forests of this equatorial isle have prevented a thorough research. A late number of the Journal of the Geographical Society of London gives about 2,000 carats as the annual product of the mines of Borneo, which have never yet yielded a diamond of 36 carats. The monopoly of the government of Holland in this matter is found to be quite profitless, and it is probable that, as in Brazil, a considerable portion of the production is abstracted by contraband trade.

The rank of a diamond can only be approximately determined by its weight. If, for example, it is not of a beautiful water, perfectly pure, colourless, and limpid, it cannot receive the title of sovereign. urthermore, if its lustre is not brilliant, it will have to be recut to render it perfect, and in this operation it will lose weight. The Regent and the Koh-i-noor are equal in beauty, but the Regent of 136 carats is more valuable than its rival, which has been reduced in cutting from 186$\frac{1}{16}$ carats to 102$\frac{13}{16}$ carats. The diamond of Tuscany is of an inferior color, a yellowish lemon. The great diamond of Russia is rather ill-shaped; it is like a pigeon-egg cut in half, with facets over its whole contour. It is only a big stone, a specis of heavy rose much too thick. If the Koh-i-noor and the Star of the South had been cut in the Sancy form, it is probable that with a brilliance equal to that of the Regent they would have surpassed it in weight. The Star of the South, when I saw it in the possesion of M. Dufresnoy at the Institute, weighed 254$\frac{1}{2}$ carats; but by injudicious cutting, I regret to say, it was reduced to 127 carats.

Permit me further to remark in regard to the Sancy form, that it always admits of a subsequent cutting into that of the brilliant, and is easily experimented upon. For this reason it is prudent not to sacrifice, until the last extremity, so much weight as must be lost in reducing a stone of the form of the Indian Brazil diamond by the ordinary cutting. I have seen at Amsterdam a model of the form which the latter would take by ordinary cutting. It will be like the Koh-i-noor, that is to say, not sufficiently thick for the size of its face.

In comparing the English diamond with the model of 100 carats given by Jeffries it will be found that its extent of face is almost double what it ought to be for a diamond properly cut.

It would be a curious speculation to follow the future history of the Star of the South after having shone at the French Exposition. What name will this sovereign diamond assume? Will it be Albert or Francis Joseph? The proud Americans, sagacious estimaters of all commercial values, will they have the ambition to possess one of these rare productions of nature? "How have you managed to put so immense a price on this pearl?" asked Phillip II of an eastern merchant. "Sire, I knew there was in the world a King of Spain to buy it."

Thus far we have said little for science in this dissertation, and yet precious stones, and, in general, all crystals, from their geometrical forms, their chemical and mechanical properties, their weight, their color, their action on light, and their electrical qualities, they all offer the most delicate as well as interesting applications of the principles of physics. Haüy convinced a crystal to be made up of an assemblage of minute parts of molecules, each having the same definite form. From a few of these elementary molecules, which he called primary forms, he was enabled to build up all the forms which occur in nature, and in so doing he was led to inquire whether the same elementary forms might not give rise to more than one derivative form, or, in other words, whether the same substance could not crystallize in more than one form. Nature replied that she had anticipated his question by producing a specimen of the anticipated form. By the application of mathematicial analysis to the fertile conception of Haüy all the forms of crystals which can possibly be produced by an aggregation of a given elementary form, as well as the forms which are incompatible with a particular elementary molecule, can be foretold, and these predictions are, in all cases, found to be in exact accord with the actual facts of observation; while the chemist and the mineralogist are continually adding to the list of crystals of theoretically possible forms, in no case has one been obtained of an *a priori* incompatible form.

Hardness is an important quality by which valuable stones are distinguished. In the cutting of the Koh-i-noor it was found that it required a whole day to produce facets which could be commonly formed in the course of three hours. It was also found necessary to increase the rapidity of the rotation of the wheel on which the diamond powder is spread. In an experiment made some years ago at the expense of the Institute, a black diamond of Borneo was put in the hands of Gallais, the diamond-cutter. On this he wore out a steel wheel and a large quantity of ordinary diamond powder without making the least impression on its surface. It lost none of its roughness, although loaded with a considerable weight, and heated almost to whiteness by the rubbing of the wheel, which revolved with such velocity as to emit a continual shower of sparks during the operation.

This intractable substance required the powder of black diamonds, like itself, to produce the desired effect, and doubtless some day the powder of black diamonds will be used to advantage in cutting the ordinary diamond, as well as in other processes of the arts. Every one has seen a glazier, with a minute point of a diamond, trace upon glass an almost imperceptible groove in the crust of the glass, which renders it easily frangible in a given direction. It is conjectured by some that the ancients in engraving on sapphires and rubies have used a diamond point as a burin, and the finish of some parts of cameos and intaglios deeply cut would appear to warrant this supposition. An art has been lost to France. Who will restore it? Since the last encouragements given to engraving on stone by the Empress Josephine and Napoleon I, everything of this kind comes to us from Italy, and there is not a single glyptic monument of the reigns which have succeeded the Empire.

The diamond is heavier than rock-crystal and lighter than white sapphire. It has almost the same weight as the white sapphire of Brazil, called *goutte d'eau*. It is often confounded with these three stones, which resemble it in whiteness. Let us see then how these may be distinguished by the weight.

It is known that if a real diamond be suspended by a fine thread from a delicate balance, and when in perfect equilibrium it be immersed in a glass of water placed immediately under it, it loses two-sevenths of its weight, or, in other words, two-sevenths of its weight in air must be added to the pan from which it is suspended to restore the equilibrium when the diamond is in the water. In like manner, a diamond weighing 21 carats loses in water about 6 centigrams. A white sapphire of the same weight loses only a fourth of its weight when weighed in water, that is to say, about 5 centigrams. A piece of rock-crystal in the same condition loses 8 centigrams. Hence, whenever any species of crystal weighed in water loses more than two-sevenths of its actual weight, it cannot be a diamond. We shall presently see how the diamond is distinguished from the white topaz, which, like itself, loses in water two-sevenths of its weight.

Chemical tests being, in general, very difficult of application, and involving a loss of the substances examined, need not here be described;. but we shall point out an optical test of a very delicate character, which traces at once the line of demarcation between the diamond and all other colorless gems; we refer to that of double refraction.

In looking through a transparent stone at a detached object, such as the point of a needle, or a small hole pierced in a card, the object is seen double, as if there were two needle-points or two holes. This phenomenon is called double refraction, and is exhibited by all white or colorless gems except the diamond. As some little dexterity is required to readily exhibit this curious property, the object to be looked at and the stone should be fixed, at the proper distance apart, on a support by a little modeling-wax, so as to be more conveniently seen by those interested in the experiment. M. Haüy was often called upon in consultations of this kind, and sometimes, in the case of a suspected fraudulent sale, he gave his testimony in court as an expert in regard to the character of gems. The white topaz of Brazil produces double refraction, and may at once be recognised by this quality as a false diamond. I have a painful recollection of a visit from an English gentleman, who brought for my examination a magnificent white topaz, which, had it been diamond, would have been of immense value. It was very easy for me, from the cutting of the stone, to perceive the double refraction; but such was the agitation of the owner, and so convulsively did his hand tremble, that I was obliged to attach the stone to a wooden ruler with a bit of green wax before I could render the phenomenon clear to him. The instant he saw the double refraction, the bearing of which I had explained, he seemed overcome with emotion; and after remaining some minutes in a half-stupified condition, he suddenly rose and abruptly took his leave, doubtless to hide his emotion, too powerful to be controlled. He afterwards sent me his card, apologizing for his hasty departure, but I never learned what great interest I had compromised or what hopes I had dissipated in thus determining the cha-

racter of the stone. In the work of Mawe, it may be seen that the white sapphire and the white diamond owe their high price to the fact that they are often fraudulently substituted for diamonds. Mawe might have added, also, the white zircon, which is heavier even than the sapphire, and which much more resembles the diamond. To exhibit one of these stones in dress as a real diamond may be only a small exhibition of vanity, but to sell one for a diamond is a felony, which, fortunately, is recognized as such by our courts of justice.

I need scarcely add that the zircon, like the white sapphire and topaz, possesses the quality of double refraction in a high degree. The test of double refraction is a very convenient one, because it can be exercised without unsetting the stone, and without any complicated apparatus. A little practice enables any one very soon to learn how to recognize the phenomenon; and this is not much to pay for gaining so absolute a means of identifying a false diamond.

Diamonds are capable of being colored in various ways. A slight tinge, as in the case of the great Tuscany and the Russian diamonds, detracts from the value; but when a diamond is found of a lively and rich color, it is very much sought after as a very rare specimen. The Marquis of Drée possesses several of this kind, and especially one of fine rose tint. The specimens which have this character are called *stones of affection*, and really their owners sometimes regard them with a sentiment which fully justifies the name. Among the crown diamonds of France there was one of triangular shape, of a fine sapphire blue, and weighing 60 carats. This disappeared at the time of the theft of these diamonds, none of which, except the *Regent*, were ever recovered, doubtless because this latter was of more difficult sale than the rest. During his imprisonment, the thief enjoyed among his companions great consideration on account of the magnitude of his villainy. On what may not distinction be based in this world?

But the wonder of all colored diamonds is the blue one, owned by Mr. Hope, the form of which has been engraved in the report of the London Exposition. Mawe characterizes it as *superlatively beautiful.* It weighs 44¼ carats, and often, according to Mr. Tennant, unites the blue colour of the sapphire with the prismatic lustre and brilliance of the diamond. Every one who has studied the play and the effect of precious stones in any brilliant evening assembly has remarked that the sapphire, sparkling as it may be by day, becomes dull and lustreless in the light of lamps, wax candles, or gas. It would be curious to know whether the same loss of brilliance happens to the blue diamond of Mr. Hope, which I do not hesitate to place beside the sovereigns in value, because, though less heavy than they, it surpasses them in rarity. The term *stone of affection* is scarcely an inappropriate name for this precious object, though it is sometimes applied with more questionable propriety. I once saw a stone at M. Bapst's, known as a *black diamond*, which had the color of a tobacco-leaf, and was only admirable on account of its singularity. Louis XVIII, however, selected it for the crown of France, at 24,000 francs, but it was never placed there. Such diamonds are always cut very thin; for what is the use of thickness in a stone which is not transparent, and of which the superficial brilliance is quite vivid? If to an amateur such a stone should become one *of affection*, he certainly would run no risk of having his taste disputed. It is curious to remark that Pliny says almost the same thing of Nonius, who, owning a beautiful opal, preferred to quit Rome as a proscribed traitor, rather than yield to Antony his *stone of affection.* "It was," says Pliny, "an astonishing instance of tyranny on the part of Antony to proscribe a citizen for the sake of a gem; but we can none the less wonder at the obstinacy of Nonius, who, rather than give up his beloved opal, suffered himself to be exiled from his country. In reading the interminable list of marvellous qualities attributed before the seventeenth century to gems, we may understand something of the extreme value set by the possessors of precious stones on these treasures. The native Indian princes are great amateurs of diamonds, and seek for them with great assiduity. In one of their collections I have seen a small natural diamond, with brilliant points, encased in the red cement which ordinarily envelopes the stone in the mine. This specimen, which was about the size of a small hazel-nut, and in which the little diamond was enshrined within the cement, formed an object well adapted to excite the wonder and admiration of the mineralogist, as well as the superstitious regard of the princely, though unscientific, owner.

Mawe states that of all values the least variable is that of the diamond. He cites various crises which have occurred in England in the quantity of diamonds received, and shows that, with regard to price, these crises have been generally very light and of short duration. There have been two great panics in the diamond market since 1840. The first was on the discovery of the new mines in Brazil, about 1843 or 1844. The second was in France, and followed the commercial shock caused by the revolution of 1848. The price of diamonds then rose and fell with other

securities, and in precisely the same proportions. The price is now about 200 francs the carat, a price indicated by Jeffries reaching to about 250 francs. M. Castelnau, in his Voyage across South America, hints that the fall in the price of diamonds came from a diminution in the taste of society for these brilliants and other frivolous decorations. If the depreciation in the value of diamonds is to depend on a decline in the taste for luxury and ostentation, a desire to shine, and even on the cupidity of man, a rich commerce in these gems may be assured in London and Paris for many centuries to come.

Without recurring to the *Arabian Nights*, or to the legends of the middle ages, where gnomes and griffins are seen jealously guarding these treasures of the earth, and only by the force of some cabal allowing mortals to obtain them, it is evident that a great value assigned to a small quantity of mineral substance has given rise to singular changes in fortune. I do not know on what foundation Mawe says that Liégés, ambassador to the court of Berlin, obtained from the King of Prussia a treaty of alliance, offensive and defensive, by dazzling his eyes with the splendor of the *Regent*, for the cession of which by France the abbé allowed the King to entertain a hope. Frequently the precious stones of sovereigns have been used as pledges for the payment of debts; but these transactions are comparatively of little interest, and we prefer much more to contemplate the incident of a poor gardener of Golconda finding in his garden a beautiful stone, which, proving to be a diamond, afforded not only ease and comfort to himself and his family, but opened to his whole country a source of riches. We also prefer to dwell on the fortune of a poor negress who found the Star of the South, in July, 1853, while washing the sands of the Brazilian mine of Bagagen. According to the ancients, Hercules presided over the discovery of treasures. By this perhaps they wished to indicate that what is truly valuable can only be attained by untiring industry. But be this as it may, the discovery of a gem was never considered by them as a favor from Hercules, but as the reward of labor.

The Astronomer Royal, in his recent report to the Board of Visitors, says, "Very lately, application has been made to me, through the Board of Trade, for plans and other information regarding time-signal-balls to assist in guiding the authorities of the German Empire in the establishment of time signals at various parts of that state. In other foreign countries the system is extending, and is referred to Greenwich as its origin."

HOROLOGY FOR THE MILLION.

In these days when so much is said about technical education, it is of importance that scientific information given in a popular form should be at least tolerably accurate, and free from the common blunders almost always made by newspaper writers when handling even the most simple scientific subjects. The article on "Remarkable Clocks," which appeared recently in "Aunt Judy's Magazine," by L. C. F., is a very remarkable article indeed. It is full of the most astonishing errors, and some most common facts are told with an air of great mystery. We only refer to the article to protest against the publication of such "facts," which confuse instead of enlightening the intelligent British public, whose minds are already sufficiently hazy on horological subjects.

We will only refer to a few of the statements to show that our censure is merited. The weight of the great bell at St. Paul's is stated to be between one hundredweight and two hundredweight," instead of five tons four cwt. The diameter is given as 10 feet, the real diameter being 6ft. 9in. The clock is spoken of as striking so loud that in 1777 it was heard at Windsor, 22 miles away. Whatever happened then, the striking of the clock now is absurdly faint. The tale about the clock striking *thirteen* is revived, though the legend has been exploded, at least as regards the present clock. The writer goes on to say that this clock was originally called "Tom of Westminster," whereas it was the bell which bore that name, not the clock. Describing the Westminster clock, he alludes to the great weight of the minute hands, the fact being that these hands weigh only 28lbs. each, which is wonderfully light when the length and size is considered. We are further informed that "the scape wheel is driven by the musical-box spring, and weighs about half an ounce"!!! Also that "this clock is said to be at least eight times as large as a full-sized cathedral clock," which conveys about the same idea as if it was said to be eight times the size of a lump of chalk. The clock is spoken of as "Big Ben," whereas it is the bell only which answers to that name. It was, we believe, named after Sir Benjamin Hall, at that time First Commissioner of Works.

The article then goes on to describe the clock now at Strasburg as being begun by Conradus Dazypodius in 1571, entirely ignoring the fact that not one single wheel in the present clock is older than 1838, when the present clock was begun, and that the original clock was constructed by the brothers Habrecht in 1372, under the direction of Dasypodius,

assisted by Wolkenstein, a Breslau astronomer. This clock ceased working in 1790, and it was not till Sept. 24th, 1833, that the question of its restoration came formally before the Municipal Council of Strasburg, and after many negociations, J. B. Schwilgue was entrusted with the entire re-construction. The work was commenced in June, 1838, and at midday on Sunday, the 2nd October, 1842, the eminent horologist set the clock going with his own hand in the presence of an immense concourse of spectators, including a large body of *savants*, who were in the city at the time, assisting at the scientific congress held there that year. The restoration of Tobias Stimmer's paintings on the framework (which is the only *original* portion of the clock) was intrusted to an Italian artist. So much of the works of the old clock as remained were deposited in a chapel in the cathedral, together with the figures, cock, and sphere, dials for showing the eclipses, &c.

In conclusion, we admit that the latter part of the article is not so bad, being more in the writer's way, as it consists of gossiping anecdotes, keeping clear of any facts or technical matters. It is, however, rather too bad to call the celebrated Tompion (whose valued portrait is one of the treasures of our Institute) Mr. Pompion. The writer might have referred to Henry de Wicks' Dover clock, and, for the benefit of his London readers, informed them that this wonderful piece of work, together with the Glastonbury clock, can be seen at the Patent Office Museum, South Kensington.

Letters to the Editor.

All letters to be addressed to the Editor, at the Institute, 35, Northampton Square, E.C.

Sir,—Mr. Christian Lange having in the last *Journal* hinted that the fusee is a useless contrivance in a good watch, only advocated to deceive the ignorant amongst watch makers, permit me seriously to ask if Mr. Lange really believes that a long weak spring of equal thickness throughout—the coils of which have a natural tendency to rub, thereby causing irregularity of friction, and further causing the vibrations to fall off a quarter of a turn when nearly down—can make a watch go as well, all things being alike, as another watch having a fusee which allows the spring in the barrel to taper inwards, in order to cause each turn of the spring to move free of the other with the least amount of friction and consequent greater regularity of action and further, pulling with equal force on the train all through? If Mr. Lange believes so, he must have a curious notion of mechanics. Mr. Lange backs up his theory not by a watch of his own make, but by a Swiss going barrel repeater which he has by him. Though practical men making both kinds of watches know full well the various merits of each kind of watch, the authorities, I have no doubt, in order to do a service to the trade, would receive the watch of which Mr. Lange speaks, at the Royal Observatory, and after having tried it for a few weeks the readers of the *Journal* would be glad to hear of the result. My only excuse for writing this is the fact that an opinion is afloat amongst men in the trade, who have no experience in timing watches, that the going barrel can compete with the fusee. This opinion is no doubt fostered by the makers of cheap going barrel watches in order to effect sales, and dealers not accustomed to any particular nicety in timekeeping no doubt in many instances find going barrels give sufficient satisfaction; but if going barrels must be made, which I consider very proper that they should, in order to meet the demands of the less wealthy, as well as to compete with foreign productions of the same class, by all means let the public know the reason [illegible] so as to prevent some from deceiving th[illegible] ignorance and others by craft, and th[illegible] buyers may know what to expect for [illegible] money. The mission of the *Horo*[illegible] *Journal* being to diffuse a correct know[illegible] of horological instruments and to r[illegible] erroneous notions, I hope to be pardoned [illegible] this intrusion.

A MEMBER OF THE BRITISH HOROLOGICAL INSTITUTE.

Sir,—Having read Mr. Schoof's remarks and description of a new barrel-hook, I venture to send a description of one which I have used a long time. My plan is very similar to Mr. Schoof's, but differs in the following particulars:—

1. I make the hook of steel wire, because I find in practice that a brass hook is very soon worn or cut off by the end of main spring, if the spring has to be taken out and put in a few times.

2. I do not tap the hole in barrel before putting in the hook.

3. I slightly taper and square the end of steel wire before cutting the thread on it.

4. I cut off the piece for the hook say, ¼ inch long and make the hook on it afterwards, on the *large* end of wire. I find it an advan-

tage to make the hook double, that is, under-cut on the two opposite sides, so that I can adjust the projecting length of the screw, which could not be done if the hook is made only on one side.

5. The tapered and squared end of the steel wire forms a tap to tap the hole in barrel, and when once screwed in, (from the inside of course) by catching hold of the small end when it is put through the hole in barrel, and screwing it round with the pliers, it does not require taking out again, and the consequence is that it fits much more tightly than if the hole is tapped first.

I have tried both ways, and both steel and brass for the hook, and find this is the best and quickest way, and steel the best material. With regard to look, it at least looks as well as a steel hook rivetted into the main spring.

Sundridge, Kent. J. VIRGO.

SIR,—I have an old turret clock which I purchased in Yorkshire some years back, and have repaired, and fixed it at the hamlet of Beaver, near Ashford, Kent, the maker's name of which I am anxious to find out. The set-hands dial, had a square hole cut out of centre of the name. Enclosed is *fac-simile*. The "London Directory of 1779" does not give any clockmakers name ending "nton." Was Moorfields at that time an outlying village? If you could give me a clue to finding the name, I shall be much obliged. The Clerkenwell men that I have asked do not seem to have met with the name.

Yours &c.,

Reigate. THOS. NICKALLS.

Abstract of the Board of Trade Returns for September, 1873.

IMPORTS.

Month ended 30th Sept.		Nine Months ended 30th September.
Clocks ..	31,961	Number .. 296,541
	£35,914	Value £318,791
Watches....	£33,158	Value £282,130

EXPORTS.

Plate, and Plated and **Gilt wares £19,761**	Value £181,547

To Correspondents.

In answer to several inquiries as to whether it is compulsory to register letters containing inexpensive trinkets, we quote the following from the circular issued by the Postal authorities in August: "Letters containing bank notes, postage stamps, jewellery, or watches. The notice lately issued on this subject, so far as relates to letters containing bank notes or postage stamps, is cancelled; and as concerns jewellery or watches is postponed till the 1st September, from which date all packets containing jewellery or watches not presented for registration, and not so packed as to conceal their contents, will be subject to a double registration fee of eightpence." On inquiry at the Post Office we were told that "anything that appeared to be valuable," if sent unregistered, would, if discovered, entail a payment of eightpence on the recipient.

L. F. MUNGER.—*Thanks for your letter. We shall have pleasure in complying with your request.*

A CLOCKMAKER.—*You will find an article on the polishing of pinions in the* JOURNAL *for March,* 1873. *We are not aware of any work giving a description of the machinery used in the making of French clocks.*

D. FORD.—*The number of teeth alone will decide the proportion. For even assuming that the wheels are correctly made, their diameters at the point of contact would not give their relative proportions exactly, although in the instance you mention the wheels must be incorrectly pitched; for the diameter of a wheel* 32 *teeth to act with a pinion one inch in diameter having* 8 *teeth should be a trifle under* 4 *in., and certainly not* 4½ *in.*

"J. J. P."—*The clock at the Lombard-street Post Office is controlled by galvanic current from Greenwich Observatory. The Westminster Clock is not controlled, but automatically reports at Greenwich its variation from mean time, which is only about one second a week.*

The engraving of my escapement in the October number of the JOURNAL *shows as if the ruby pins* d *and* e *were merely to catch the teeth of the escape wheel, but they are not only for that purpose, they are to be so placed that the teeth of the escape wheel act upon them like upon a lever.*—F. T. KRAUTH.

Could some of your correspondents kindly explain the following. I am told by those who have greater experience than myself that "in trying a lever escapement, if you find the wheel and pallet depth a shade shallow and your roller pin has too much shake in the notch, that by putting a larger pin you make the wheel and pallet depth deeper." Now, it appears to me

that, supposing the pin to be deep enough in the notch, whether it be large or small, so soon as the wheel leaves the impulse face of one pallet it drops on to the opposite locking, and that no alteration in the size of the roller pin can possibly bring that locking any deeper into the wheel at the moment the tooth leaves the impulse plane, as they necessarily travel together. If I am wrong, perhaps some one will kindly set me right.—Junior. [*"Junior's" conclusion is correct, and "those of greater experience" than himself must have a profound ignorance of mechanics. The amount of locking is dependant on the shape of the pallets alone, and the only result of the ruby pin having too much shake would be that a portion of the impulse given to the pallets by the 'scape wheel would not be transferred to the balance.*]

Reply to the questions of "S. L." in the September number of the Journal.—*Close the banking pins as much as possible, and if that does not cure it sufficiently the lever is too short. In order to ascertain whether roller and fork are pitched to the right depth, cause a frictional resistance to act upon the lever by pushing some folded-up paper underneath, or press the lever gently against the roller pin in a contrary direction to the motion of the balance, and in leading the balance to and fro the wheel should escape from either pallet. Make the pivot in the ordinary way, leave it a little thicker than required, break the shoulder till very little of it is left, and finish the pivot on a good Swiss pivot-tool with an ordinary burnisher, of which the corner is rounded off, taking care to press the burnisher slightly against the shoulder. If sufficiently fine emery is used to sharpen the burnisher the polish becomes perfect. In a tool where the pivot runs free, gunmetal with diamantine mixed with oil to the consistency of paste produces a perfect polish. Use very little diamantine. The term "a turn and a half" for a vibrating balance means exactly what it expresses. As a balance may be turned about a whole turn on either side of its point of rest before the roller pin comes in contact with the fork, the whole vibration may comprise about two turns.*—M. I.

Jewellery and other articles of value entering Queensland being chargeable with Custom's duty, the Postmaster-General desires it to be known that letters or packets containing jewellery or other valuables addressed to Queensland are, by the Colorial laws, liable to detention until the amounts of the Custom's duty is paid.—[In forwarding letters containing jewellery, expedition in the delivery will probably be ensured by advising the correspondent in a seperate envelope.]

British Horological Institute.

DIARY of MEETINGS for NOV., 1873.

DAY.	DATE	TIME.	BUSINESS.
Monday	3	8.0	Technical Class.
Tuesday	4	7.30	Journal Committee.
Tuesday	4	8.30	Council.
Thursday	6	8.0	Technical Class.
Monday	10	8.0	Ditto.
Thursday	13	8.0	Ditto.
Monday	17	8.0	Ditto.
Thursday	20	8.0	Ditto.
Monday	24	8.0	Ditto.
Thursday	27	8.0	Ditto.
Thursday	27	8.0	Financ eCommittee.

The Exhibition of Work, at the Institute, will be open from the 10th to the 15th, and from the 17th to the 22nd, between the hours of 11 a.m. and 9 p.m.

MEAN TIME OF THE SUN'S SEMIDIAMETER PASSING THE MERIDIAN OF GREENWICH, AND EQUATION OF TIME TABLE.—November, 1873.

Day of the Month.	Mean time of the Sun's Semidiameter passing the Meridian.		Equation of Time *to be subtracted from* Apparent Time.	
	M.	S.	M.	S.
1	1	6·8	16	17·4
2	1	6·9	16	18·2
3	1	7·0	16	18·2
4	1	7·1	16	17·4
5	1	7·3	16	15·7
6	1	7·4	16	13·2
7	1	7·5	16	9·9
8	1	7·6	16	5·7
9	1	7·7	16	0·6
10	1	7·8	15	54·7
11	1	8·0	15	47·9
12	1	8·1	15	40·3
13	1	8·2	15	31·8
14	1	8·3	15	22·4
15	1	8·4	15	12·2
16	1	8·6	15	1·1
17	1	8·7	14	49·1
18	1	8·8	14	36·3
19	1	8·9	14	22·7
20	1	9·0	14	8·3
21	1	9·1	13	53·0
22	1	9·2	13	36·9
23	1	9·3	13	20·1
24	1	9·5	13	2·5
25	1	9·6	12	44·2
26	1	9·7	12	25·1
27	1	9·8	12	5·4
28	1	9·9	11	44·9
29	1	10·0	11	23·8
30	1	10·1	11	2·0

THE EXHIBITION OF WORK AT THE INSTITUTE.

Report of the Judges.

WE beg to report the result of a careful examination of the work connected with chronometer, watch, and clock making, placed in competition for the prizes offered by the Council of the British Horological Institute, as follows :—

Taking the specific prizes in the order given in the conditions, we award the prize of five pounds for the best chronometer escapement to George Abbott, for an exceedingly fine piece of work. To this exhibitor we also award the silver medal of the British Horological Institute, for the best specimen of work in the exhibition. To T. Nelson we award honourable mention for a chronometer escapement, also of fine quality.

We award the prize of five pounds for the best lever escapement to J. L. Tilling; also an extra prize of three pounds to R. Bridgman, for a lever escapement of very great merit, and to W. Smith, of Coventry, honourable mention for three escapements.

For the best watch finishing we award the prize of five pounds to R. Gore, and honourable mentions for watch finishing to R. Foster, W. Owen and F. T. Lawrence. We award also a prize of two pounds to W. C. Smith, an apprentice, aged eighteen, for a very creditable specimen of watch finishing.

We experienced some little difficulty in dealing with the specimens of keyless work exhibited. With the exception of the work of an apprentice, all the keyless mechanisms were upon the same principle, and all very excellently executed. Unable to detect sufficient difference in the work to justify us in giving the prize to any one competitor, we award honourable mention for keyless work to C. Finegan, C. V. Nyman, G. Sutton, and Thomas Buck

The prize of five pounds for the best made and applied balance-spring we award to G. Morton, and we award an honourable mention to H. Webber, for balance-spring made and applied. We desire to express particular commendation of the manner in which a Breguet spring is applied in the work of both these competitors.

We award to — Andrews the sum of five pounds for the best made case, and to John Martin we award honourable mention for very good specimens of case making.

From the sum at our disposal for prizes unspecified we award a prize of five pounds to W. Sills, for chronometer finishing; a prize of two pounds to J. Ody, for a Kullberg's marine chronometer balance; a prize of two pounds to Mrs. Mann, for pivoting of exceedingly fine quality; a prize of one pound to H. Lee, for fusee and spring block cutting.

We also award honourable mentions to the following:—R. Bridgman, for measuring tool; Fraser, for improvements in slide rest and mandril; W. Twitchings, for an interesting display of watch dials and enamels; Reymond Brothers, for wheel cutting; F. Harris, for watch engraving.

The quality of the work exhibited by many of the competitors is exceedingly good, and in some instances we have had difficulty in awarding the specified prize, owing to the work of two competitors displaying almost equal merit; but we note with regret that the show of tools is very meagre.

(Signed)

C. WHEATSTONE,
V. KULLBERG,
J. Mc LENNAN.

The exhibition of work in the chronometer, watch and clock making trades, the particulars of which have been for some time announced in the Journal, opened on Monday, November 10th. The specimens of work exhibited, though not so numerous as might have been expected, considering the inducements held out in the shape of money prizes, &c., were nevertheless exceedingly interesting and for the most part of a very high order of merit. The judges appointed were Sir C. Wheatstone, at the instance of Lady Burdett Coutts, Mr. V. Kullberg by the Council of the Institute, and Mr. Mc Lennan as Exhibitors' judge, he having received the majority of votes. Their joint report, published in the preceding page, specifies the various exhibits to which awards have been given, and, following the classification observed in the report, we proceed to describe those of the objects exhibited which we think likely to be of general interest to our readers.

Of marine chronometer escapements the one exhibited by George Abbott has received not only the highest prize in its particular class, but has also been adjudged worthy of the silver medal of the Institute as being the finest specimen of work in the exhibition. It must certainly have been not less profitable than interesting for the visitors to note the exquisite shape of the pivots, the uniform squareness even in its most delicate parts, combined with the highest degree of finish observed in this escapement, which is indeed in every way worthy of the high position accorded to it by the judges. A marine escapement by T. Nelson which has secured an honourable mention presents many features of excellence, its high degree of polish being especially noticeable. A finely made stud and steel collett are included in the exhibit.

A significant feature of the exhibition is the entire absence of pocket chronometer escapements, which may be accounted for by the high position now occupied by the lever escapement for pocket watches, the accurate production of which, therefore, becomes a matter of vast importance to the trade. J. L. Tilling takes the chief prize, with two escapements, one a double roller, the other a single pin of the ordinary construction. It would be almost impossible to imagine finer work than is here displayed. The greatest attention to detail is evident, not merely in the finish of the various parts, but also in proportions, freedoms, shakes, weight of levers, &c. The double roller has a solid circular banking screwed on from the back of the plate. The jewelling of these escapements by F. Allamand must not be passed over without a word of praise. A reference to the report will show that an extra prize in this class was awarded to R. Bridgman for his double roller escapement with triangular pin. The noticeable features of this escapement, apart from the workmanlike ability shown in its production, are a gold lever (which by the way we think objectionable from its weight), and a circular screwed banking planted flush with the plate and very nicely executed, as are also the Breguet stud and index attached. Three double roller escapements, of more than average merit and to which an honourable mention has been given, were shown by W. Smith, of Coventry.

R. Gore is the successful competitor in the class for watch finishing with a very fine example of half plate work. The delicate handling, uniform squareness, and thorough roundness observable in this watch are worthy of all praise. Especially observable is the manner in which the fusee top pivot has been lengthened by turning back, so as to ensure a long hole in the fusee piece and the consequent retention of the oil, a point too often neglected even by high class workmen. The solid stop work also is filed up in a really artistic manner, and its lightness of action ensured by the spring being weakened in a more than usual degree. The pivoting is as near perfection as possible, and the care displayed in polishing the jewel setting, screws, &c. is especially commendable. The gilding of this watch by R. Binckes should not be allowed to pass unnoticed; it is the finest we have seen for some time. Honourable mention is given to R. Foster for his half plate keyless watch with reversed fusee. The finishing of this watch possesses many commendable features. The now almost obsolete practice of polishing the train wheels is revived in great perfection. The Breguet stud is placed squarely and uprightly on the cock, and is altogether well finished. F. T. Lawrence, who exhibits four watches, one a ¾ plate of ordinary construction, a ¾ plate centre seconds, a ¾ plate going barrel keyless, and a ½ plate with reversed fusee, gains an honourable mention, as does also W. Owen with a ½ plate pocket chronometer. A gratifying feature of this department is the awarding of a special prize to an apprentice, W. C. Smith, for a specimen of ¾ plate finishing, remarkably good considering the age of the youth; we only regret that more apprentices have not displayed a similar spirit of emulation, and given us specimens of their work. This is the only prize awarded to an apprentice in the exhibition. The unusual number of honorary awards bestowed for watch finishing testifies to the general excellence of the work sent in for competition.

It will be seen from the report that the dges were unable to award a prize for key-s work, from the uniform excellence of the hole of the work sent in, and have therefore ven honourable mentions to L. Finigan, C. . Nyman, G. Sutton, and Thomas Buck. In stice, however, to these competitors it must stated that their manipulation was of a ry high order, and we are not surprised that e judges should have declined to give the e-eminence to anyone. The principle of e mechanism was in each case the same, ing the excellent arrangement introduced Mr. Kullberg for fusee watches, and fully scribed in No. 128 of the *Journal*.

For the best made and applied balance-ring, the judges awarded the prize to Geo. orton for his very beautiful Breguet spring thout an index, the shape, action, and polish which, together with his collection of ight and blued springs, attracted general ad-ration. The wire of which these springs re composed was made by the exhibitor by improved process, whereby the inequalities substance so perplexing to makers of lance-springs are entirely avoided. An ex-ination of the wire exhibited disclosed a autiful uniformity of surface very highly lished, and with exquisitely rounded and lished edges. It must have been this arked superiority of wire which turned the lance in his favour, in competition with H. ebber, whose Breguet spring, also without index, can scarcely be said to be inferior, ther in make, shape, or application, and to hom an honourable mention was awarded. Nelson was also a contributor to this class ith balance-springs made and applied.

Following the order observed in the report, e come next to the gold case making, in hich Andrews with his three hunters carries f the palm. These cases are splendid ex-aples of the goldsmith's art. Their beautiful mmetry is a pleasure alike to the eye and the nd, the fit of the bottoms, bezels and domes faultless, and the distribution of the metal admirable, as is also the squareness of the arings and their general finish. But perhaps eir most pre-eminent feature is the jointing, praise of which we feel that too much can-t be said, for, though fresh from the maker's nd without having been manipulated by the int finisher, the lines of the joints are scarcely rceptible, so admirable is the fit. The ex-bitor is also very successful with his speci-ity of the turning pendant. Scarcely less mirable are the cases shown by J. Martin, oduced under his improved system of manu-ture, the tools and gauges for which accom-ny his work. Especially worthy of notice the cutting tool, for producing the beadings of bezels and bottoms at one stroke; and his mode of making middles for double bottomed cases, in two pieces with three solderings, instead of following the usual method in which three pieces are employed, necessitating five solderings. A very light case by this exhibitor weighing only 12 dwts. 18 grs. for a 4-size movement, and yet admitting of a deeply engraved outer bottom, attracted considerable attention. A collection of German silver cases for railway guards' timekeepers was exhibited by J. Walton.

A point of particular interest to the visitors was the specimen of marine chronometer finishing by W. Sills. The two-day marine chronometer, from the size of its pinions, &c., presents an unrivalled opportunity for the display of the finisher's art in the use of the graver; this advantage has been worked out to its fullest extent in the movement under notice. The tyro in the art of turning might gather most useful lessons from a study of the deep clean cut hollows of elegant shape, but in which soundness is never for a moment lost sight of. The shape and polish of the arbors, pivots, &c., were also much to be commended. For this exhibit a special prize of £5 was awarded. The other special prizes given were one of £2 to Mrs. Mann for her very excellently pivoted marine chronometer balance staff with roller, and scape wheel and pinion, and to J. Ody a similar sum for a Kullberg's flat rim balance of very fine quality. A prize of £1 to H. Lee for fusee and balance-spring block cutting, whose collection of right and left-handed fusees of all sizes, and blocks of various shapes, formed an interesting display.

Well worthy of the honourable mention awarded was the most attractive and interesting case exhibited by W. Twitchings, showing the manufacture of enamelled dials in every stage, from the rough copper and enamel of various colours to the completed dial of almost every conceivable size, form, and tint. There were dials bearing the Turkish, Persian, and other numerals, as well as the Roman and Italian figures, plain and ornamental. Dials with glass centres, brilliant as well as opaque, some with sunk centres of more than one colour; others with figures of gold and seconds piece to match. One large dial with sunk centre, and having every figure sunk, was regarded as a masterpiece of the enameller's art. Throughout, the whole of the display was very meritorious.

We examined with much satisfaction the case of Reymond Brothers, comprising a selection of steel wheels and pinions for keyless work, cut by them at their Clerkenwell establishment. We hail this fact with peculiar

gratification, as introducing a new branch of the trade to Clerkenwell, which has hitherto been supplied for the most part by German and Swiss-cut wheels and pinions, and we must pronounce, as the result of our examination, that these wheels and pinions are not to be surpassed by any we have seen. Reymond Brothers received an honourable mention for their exhibit.

The only watch-plate engraving exhibited was a very creditable specimen by F. Harris, for which an honourable mention was given by the judges.

Passing over for the present the miscellaneous articles exhibited, we come now to the display of tools. One of the largest exhibitors was Mr. Fraser, of Kenilworth, who received an honourable mention for a variety of tools of his own make, all of which present points of interest, and occasionally evince considerable inventive talent. We have first a mandril with improved slide rest. The improvement consists in the rest being attached to the mandril in such a manner that when out of use, it can be turned by means of a joint, to the side, allowing the ordinary tee rest to be used, without the loss of time involved in detaching the slide rest, as in the ordinary form of mandril. Besides this advantage, the slide rest retains its depth of cut in being brought back to its original position. The cutter has also a very wide range, and can be raised or lowered at pleasure.

Claiming attention is a mandril head, in which the dogs, instead of being made to grip the work in the usual manner by means of a screw driver, are closed by drawing the inner jaw outward by turning a nut with the thumb and fingers. A parallel opening between the jaws at all times is ensured by making the nut which is turned by the thumb and finger, engage a second nut, working upon a screw of exactly the same pitch and pressing upon the dog at another point. The idea embodied here is certainly ingenious, but we have doubts of its practicability, fearing that but few watchmakers possess sufficient strength of thumb and finger to make it effective.

Next comes a revolving slide rest with eight cutters, for movement and cap making, the object being to bring cutters of various shapes, as may be required, to act upon the work instantly, instead of losing the time necessary to remove one tool from the holder and insert another.

Shewn by the same Exhibition is a self-centreing chuck for gripping perfectly true, by means of four dogs travelling simultaneously. Also a pivoting guage for machine-made movements, and many more tools and contrivances of interest which we have not space to describe in detail. A watch, however, made entirely by the Exhibitor has a stop work of his own invention, which is worth recording. The going barrel is made on the American plan, in which the rim of the barrel only revolves while being wound. Pressing on the outer coil of the main spring is a tongue working on a pivot, through a shot in the rim of the barrel, and which following the main spring upon the winding being completed, leaves the aperture in the rim of the barrel sufficiently open to admit of the entrance of a click which is screwed to the plate and held in position by a circular spring.

The finely made measuring tool for which R. Bridgman obtained honourable mention was fully described in the November number of the journal.

An examining tool was exhibited by Wm. Gibson of Newcastle-on-Tyne, who claims for it many advantages over the ordinary depthing tool. A description would be unintelligible without a diagram for which we have no time or space in the present number.

A useful scraper having its cutting surface shaped to suit the snaps of a bezel, so that bezels and the like may be eased without impairing their shape, exhibited by Christian Lange, calls for no special remark, nor does a tool for extracting rivets from chain by W. Parsons. Two cases comprising Lancashire and Swiss tools were lent by Messrs. Haswell and Son, and Messrs. Grimshaw.

Returning to the general exhibits, a gridiron pendulum invented by J. G. Ulrich, was exhibited by C. Leach, having provision for altering its length so as to indicate either solar or sideral time, and springs to sustain the weight of the pendulum bob, so that the pressure upon the ends of the compensation tubes may be very little. Evidently an ingenious conception, worthy of a fuller description which our limited space does not admit of.

W. H. Crouch, of Cambridge, exhibited a newly contrived detached seconds, model of improved detached escapement, and a model of proposed new detached escapement, of which we hope to have a full description hereafter from the inventor. W. E. Perrett exhibited models to show his improvement on Lund's well-known detached winder.

There were some very finely made watch hands by Hazleden, of gold, and bright and blued steel. Compensation balances for watches, by C. Killick, J. M. Butt, of Liverpool, also exhibited chronometer and watch compensation balances to which was attached his screwed adjustable collett.

The very fine case engraving by R. Morris, as well as the heraldic engraving by McDavitt elicited universal admirasion.

Regulators with Denisons double three legged gravity escapement were exhibited by John Evans. A design for clock dial by Thwaites Brothers. An eight day time piece showing dead seconds made entirely of sheet metal by James Cohen.

A verge watch, pivoted, polished, escaped, finished and sprung to time by exhibitor was shewn by J. Johnson.

G. Ganney, of Tunbridge Wells exhibited a Lever watch with going barrel on the American principle—having an up and down indicator, the movement made and finished, escapement made, balance cut, sprung to time, index and hands made by himself.

Many other objects of interest were exhibited by members and friends of the Institute, not for competition, of which we can give no description in the present number for want of space.

The Council of the Institute may be fairly congratulated upon the success of their effort to sustain the high character of English work by encouraging a spirit of emulation among the workmen in the various branches. At no time has the want of a more suitable building for the Institute been felt than during the exhibition, which was visited by nearly three thousand persons during the fortnight it was open, including many members from the provinces and Scotland.

It must be some gratification to the Council that their effort to maintain the character of English work has been countenanced by all the leading papers. The *Times*, closing a full review of the exhibition, remarks, "It can hardly fail to lead to a much more considerable display in future years, as well as to a more extended knowledge of the merits of English watchmakers."

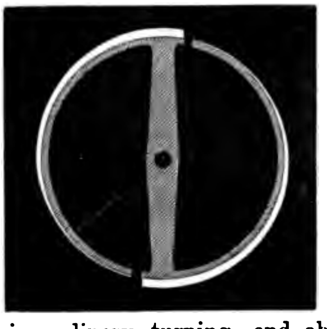
Compensation Balances.

I SEE that the subject of compensation balances is attracting more attention. Allow me to call your attention to a balance I devised some seven or eight years ago, and a description of which appeared in the *American Horological Journal*, but so far as I know it has not been used; I still think it a superior balance, and worthy of a fair trial:—

The ordinary compensation balance does not compensate for all temperatures, but only accurately for the two extremes to which it may have been adjusted, and gaining in intermediate temperatures.

To obviate this error a large amount of time and experimenting has been given, with more or less success, but I believe perfection has not yet been obtained. The usual proportion of the brass outside of the steel rim is about 3 to 2, this giving nearly twice the thickness of brass that there is of steel. I have frequently asked the question, What is the brass for, unless simply to alter the curve of the rim by its greater expansion and contraction in different temperatures? If this is the sole reason, there seems to be an error in the usual construction. I have seen some rims where the brass was no thicker than the steel, and these were much more sensitive to changes of temperature, and were more readily adjusted. In a very thick rim there is a tendency in the brass to set more or less, from the unequal tension, and the rim is not so sensitive to moderate changes of temperature, and seems to act more irregularly than thinner rims.

This subject is one that I have given much thought to for several years; and to obviate some of these irregularities, I propose the construction herewith presented, which has the brass at first turned down to about 3 to 2, and then cut through the brass where the rim is to be cut open, and turn the brass a true taper from the arm to this cut, leaving it no thicker than the steel at the cut. By placing the balance out of centre (in the direction of the arm), just enough to make the required difference in the thickness, it can be readily turned with a fixed tool in the slide rest, swinging or turning the mandrel forward and back, the notch in the rim allowing the chip to run out. With a lathe properly arranged for this purpose, the mandrel could be



run as in ordinary turning, and about as rapidly. If the screws are so placed as to divide the weight into two or three masses, say one part at the end of the cut rim, another at about the centre, and the rest used to correct and finish the adjustment, I believe that an accurate adjustment for all temperatures can be made by means of this balance; the thin part being so much more sensitive, that the principal adjustment for temperature can be made near the cut end, and the adjustment for extremes made in another part of the rim.

The screws to all compensation balances should have small or conical shoulders, so as to bring as small a surface in contact with the

rim as possible; for if the bearing against the rim is at the outside diameter of the screws, it will interfere with the free action of the rim until the expansion and contraction frees them from their bearing, and then perhaps they are found to be loose. The balances are (many of them at least) hammered or rolled before the final turning, to condense the brass and add to its stiffness. It seems to me that either of these processes cannot make the density uniform; and to obviate any error that may arise from these defects I would use a series of holes, made as for drawing wire, and force the disc of steel and brass through them by means of a flat end punch that just filled each hole in the plate. But few sizes would be required for this purpose.

L. F. MUNGER.

Rochester, N. Y.

MEASURING TOOL FOR LEVER ESCAPEMENT.

I have read with great interest the article on "Measuring Tools for Lever Escapement" in your last issue by R. B. The author of this memoir mentions my prize essay and points out an error committed by me in drawing the lifting the angle of the entrance arm. I think it willl gratify R. B. that I discovered this error soon enough to correct it in the French edition of the prize essay (published 1867), of which I send you by to-day's post a proof-sheet and copy of the corrected diagram for R. B.'s inspection.

But it seems that it would also produce an incorrectness to state the difference arising out of this error to be 2° in all cases, for it is sensibly less in a circular pallet, and as the subject has been taken up, it will be just as well to clear this matter completely.

In the circular pallet the error in question is a very trifling one (about $\frac{3}{8}$ of a degree) and can be neglected altogether.

In a pallet with equi-distant lockings, like the one spoken of by R. B., the error is of some consequence and would result in a sensible diminution of lifting angle. Still, its extent is not the same for both arms of the pallet, though the linear variation of the circle from the tangent for the breadth of pallet arms is equal on both sides. The angle resulting from it is smaller at the second pallet arm because the distance from the centre of pallet is greater than with the first arm. For the first arm it is nearly $2\frac{1}{4}$° and for the second arm $1\frac{1}{8}$°.

The escapement with the club-toothed wheel, if it has equi-distant lockings, is subject to the same correction, though lessened by the share of breadth allowed for the wheel teeth.

Since R. B. expressly invites criticism and as one good turn deserves another, I beg to point out an error in his explanation about finding the length of lever, though I think it likely he may have found it out by himself in the meantime.

Let b c be the acting length of lever and a b the acting radius (not diameter) of the roller, and a c the distance of centres. Suppose both parts to be in contact in the line of centres, the arcs of circles described from a and c clearly show a sensible penetration. On the other hand, if the sum $a\,b + b\,c$ were equal to a c, as R. B. represents it, there would be only a moment of action at the line of centres and all action would cease at ever so little distance from this line. I keep for further explanation to the first example given by R. B., where a centre distance of 0.2 and an acting radius of roller of 0·05 are supposed, and the lifting angle of roller is to be three times as large as that of the lever.

The solution on this basis is impossible, as I intend to show, for if the centre distance and the acting length of roller and its angle are given, the length of lever and its angle are determined. (Compare my own edition of the "Essay on the Lever Escapement," p. 136,—11.) It would be just as impossible to construct a triangle with all three angles given and the length of more than one side optionally put down.

In a case where the centre distance is given, as well as the angle of lever and acting radius of roller (*i.e.*, when the lever of a finished watch must be replaced), the acting length of lever must be found, and the lifting angle of roller must be accepted such as it results from the circumstances. I refer again to the diagram:—

Given in the triangle $a\ b\ c$:

$a\ b$ (acting radius of roller) $= 0{\cdot}05$.

$a\ c$ (distance of centres) $= 0{\cdot}2$.

$\wedge$ C (one-half of lifting angle of pallet $= 4°$.

$$\sin. B = \frac{a\,c \sin. A}{a\,b} = \frac{0{\cdot}2 \sin. 4°}{0.05} = \frac{02{\cdot}00698}{0{\cdot}05}$$

$$= \frac{0{\cdot}01396}{0{\cdot}05} = 0{\cdot}2792.$$

$\wedge$ B $= 163°\ 47'$

$\wedge$ A $= 180° - (\wedge B + \wedge C) = 180° - (163°\ 47' + 4°) = 180° - 167°\ 47' = 12°\ 13'$.

The lifting angle of the roller resulting from the given lines and angle is thus $= 2$ A $= 25°\ 26'$ or nearly $25\frac{1}{2}°$.

$b\ c$ (the acting length of lever) is:

$$= \frac{a\,b \sin. A}{\sin. C} = \frac{0{\cdot}05 \sin. 12°\ 13'}{\sin. 4°} = \frac{0{\cdot}05.\ 0{\cdot}2116}{0{\cdot}0698}$$

$$= \frac{0{\cdot}01058}{0{\cdot}0698} = 0{\cdot}1516.$$

I trust "R. B." will receive these few remarks in the same spirit I make them, that is with the intention of removing as much as we can the difficulties in the correct and reliable execution of this important escapement. There can be no personal disregard in assisting each other to attain so commendable a aim.

M. GROSSMANN,

Watch Manufacturer.

Glashütte, Saxony.

Ear Tube for Watch Work.

(*a*) Brass tube about $\frac{1}{8}$ inch diameter; (*b*) brass tube sliding with some friction inside tube (*a*); (*c*) short tube at right angles to (*b*) and joined to it. Not too thick tubing.

Place end (*c*) in right ear and other end (*a*) on cock of watch or near escapement, and at same time look at part you wish to see through eye-glass, and you will be able to hear the beat and see the action through eye-glass at same time. The tube (*a*) sliding over (*b*) is to adjust length to focus of eye-glass. Stopping up the end of (*a*) with cotton wool or a bit of paper prevents any extraneous sounds being heard.

I have had this tool in use about six years, and find it very useful for detecting faults in escapements, depths, &c., as it is a great advantage to be able to see a watch and hear it too at the same time.

I once spent a whole day trying to ascertain the best means to increase the loudness of the beat of Geneva and other small watches and often trying lots of different materials, &c.

I found a small thin tin box large enough to hold the watch lying flat on the bottom, and applying open end of box to the ear about as good as anything, if not the best.

A common percussion cap box about the same diameter as width does very well. It increases the sound very much, and I have detected many a fault by this means.

J. VIRGO.

Sundridge, Kent.

A CARILLON on the plan so successfully introduced at Worcester Cathedral through the exertions of the Rev. R. Cattley, is to be constructed for the new tower of Cattistock Church, Dorchester. The bells, 29 in number, varying in weight from $18\frac{3}{4}$ cwt. to 22lbs. are being cast by Severin Van Aerschodt, the famous Belgian founder, and Messrs. Gillett and Bland are making the carillon machine.

IN 1858, a mechanic in Bohemia invented a musical clock-bed, which was so constructed that, by means of hidden mechanism, a pressure upon the bed caused a soft and gentle air of Auber's to be played, which continued long enough to lull the most wakeful to sleep. At the head was a clock, the hand of which being placed at the hour that the sleeper wished to rise, when the time arrived the bed played a march of Spontoni's with drums and cymbals, and musical thunder enough to rouse the seven sleepers.

THE art of making diamonds has been almost as eagerly sought as that of producing gold. The problems are not, however, the same in principle, since to make a diamond is simply to crystallize carbon or charcoal; while in producing gold the alchymists attempted to change the very nature of bodies, and to make gold of all things. Modern chemistry having burnt the diamond, and discovered that the product of its combustion is the same as that obtained by the burning of charcoal, we would suppose that some peculiar compound of charcoal might be found which, submitted to such process as would allow the carbon to separate very slowly in a condition of perfect stillness, would produce regular crystalline forms.

ABSTRACT OF THE REPORT ON THE LIVERPOOL OBSERVATORY FOR 1872.

By JOHN HARTNUP, Esq., F.R.A.S.

Transits of stars were observed for time on 140 days, and on each occasion the errors and rates of two sidereal clocks were ascertained. During the intervals between two consecutive series of observations, each sidereal clock has been compared with the normal mean time clock, at 10 a.m. daily, by coincident beats, and the error of the normal clock has thus been obtained in terms of each of the sidereal clocks. It has, however, been found to be unnecessary to alter the time of the normal clock between consecutive series of observations; and, consequently, the rate of the normal as well as the rates of the two sidereal clocks has been renderedavailable. When, from astronomical observations, the normal clock is found to be a fraction of a second fast or slow, a vessel containing small shot is removed from a projecting piece on the pendulum-rod, and shot taken out or added, so as to change the rate, and gradually bring the clock to correct time. Records of the error of this clock at 10 a.m. each day, and of the observed time by it that the flash of the gun is seen, are preserved for future reference. Duplicate comparisons with the normal clock have been made at 10 a.m. daily, Sundays excepted, of all the chronometers sent to be tested. To these comparisons the clock errors found subsequently by astronomical observations have been applied, and the error and rate of each chronometer have thus been found from day to day. All the chronometers sent to the Observatory to be tested have been subjected to a change of temperature of fifteen degrees at the end of each week, and the extreme range of temperature has been from 55° to 85° of Fahrenheit. The temperature has been changed on each Saturday morning, and the difference of error on Greenwich mean time, found from the comparisons on Saturday and Monday, has been divided by two for the first day's rate of each week; the other five daily rates are for an interval of twenty-four hours each. . . . The rates of all chronometers are affected more or less by change of temperature. In a large majority of them the amount of change in the rate for a given change of temperature is so regular that when once ascertained correctly from a trial on shore, it may be predicted for subsequent voyages in variable climates. The mariner has no means of making observations of such refinement as to enable him to judge correctly of the quality of his chronometer before he takes it to sea; but it is practicable to supply him with a record which enables him to see the difference between a good and a bad instrument, and to furnish him with data, by means of which he can apply corrections for unavoidable imperfections in his instruments. The following examples and the results deduced from them show the practical importance of such information being supplied to the mariner.

In the succeding four examples, the rates are given for three definite temperatures only, but I hope in this report to be able to show that, from the data given in these examples, the change of rate due to error of thermal adjustment may, by a short and simple computation, be found for any other temperature to which the instruments may happen to be exposed. In the meantime, it is my desire, first, to draw attention to the advantages of a test which provides the means of selecting instruments adapted for the temperatures to which they are likely to be exposed. If this were attended to, the calculations necessary for finding the amount of change in the rate due to imperfect thermal adjustment might, on short voyages, be neglected without risk of any important error. Of the four examples here given, numbers 727 and 863 are best adapted for ordinary voyages. In No. 863, the change of rate between 55° and 85° amounts to but little more than three-quarters of a second a day; whereas the change of rate in numbers 731 and 816 amounts to six seconds a day, for the same range of temperature. This arises from the circumstance that No. 731 is adapted for an average temperature of about 9°, and No. 816 for an average of about 104°. If the advantages of an efficient trial were rightly understood, no one, to whom this Observatory is accessible, would think of using a chronometer for the important object of finding the longitude of a ship at sea, without first having it tested for error of thermal adjustment; but the object for which chronometers are received at the Observatory appears to be very generally misunderstood. Possibly this may be owing to the term "rating chronometers" being used to express two very different things. The professional rater receives chronometers for the purpose of rating them during the time that the ship is in port; on the ship sailing, he, from the best knowledge that he can obtain of the rates on shore and at sea during previous voyages, forms an opinion as to what the rate is likely to be during the next voyage; if the rate on shore differs little from the rate at sea, the shore rate is usually given, but if the difference should be considerable, the sea rate, or something intermediate between the two, is at the discretion of the rater, adopted

ROTATION NUMBER.

727

DATE.	DAILY RATE. Gaining	DAILY RATE. Losing.	Mean Temperature Fah.
1872.	SECS.	SECS.	DEGS.
February .. 19	·	2·3	55
,, .. 20	·	2·4	55
,, .. 21	·	2·6	55
,, .. 22	·	3·3	55
,, .. 23	·	3·1	55
,, .. 24	·	3·5	55
Mean....	·	3·03	55
February .. 26	·	1·8	70
,, .. 27	·	2·0	69
,, .. 28	·	1·8	69
,, .. 29	·	2·4	70
March 1	·	1·4	71
,, ... 2	·	2·3	71
Mean....	·	1·95	70
March 4	·	3·3	85
,, ... 5	·	3·3	85
,, ... 6	·	3·2	85
,, ... 7	·	3·0	85
,, ... 8	·	3·0	86
,, ... 9	·	3·0	85
Mean....	·	3·13	85
March 11	·	2·1	69
,, ... 12	·	2·0	70
,, ... 13	·	1·6	71
,, ... 14	·	1·6	70
,, ... 15	·	2·1	70
,, ... 16	·	1·4	71
Mean....	·	1·80	70
March 18	·	3·2	56
,, ... 19	·	2·6	55
,, ... 20	·	2·2	55
,, ... 21	·	2·6	56
,, ... 22	·	3·4	54
,, ... 23	·	2·8	54
Mean....	·	2·80	55

ROTATION NUMBER

731

DATE.	DAILY RATE. Gaining	DAILY RATE. Losing.	Mean Temperature Fah.
1872.	SECS.	SECS.	DEGS.
February .. 19	3·6	·	55
,, .. 20	4·1	·	55
,, .. 21	3·7	·	55
,, .. 22	3·8	·	55
,, .. 23	3·7	·	55
,, .. 24	3·6	·	55
Mean....	3·75	·	55
February .. 26	1·0	·	70
,, .. 27	1·7	·	69
,, .. 28	1·8	·	69
,, .. 29	1·3	·	70
March 1	1·2	·	71
,, .. 2	1·0	·	71
Mean....	1·33	·	70
March 4	·	2·3	85
,, .. 5	·	2·1	85
,, .. 6	·	2·2	85
,, .. 7	·	2·2	85
,, .. 8	·	2 5	86
,, .. 9	·	2·2	85
Mean....	·	2·25	85
March 11	0·9	·	69
,, .. 12	0·9	·	70
,, .. 13	0·9	·	71
,, .. 14	0·8	·	70
,, .. 15	1·3	·	70
,, .. 16	0·9	·	71
Mean....	0·95	·	70
March 18	3·5	·	56
,, .. 19	3·9	·	55
,, .. 20	3·8	·	55
,, .. 21	3·6	·	56
,, .. 22	4·1	·	54
,, .. 23	4·1	·	54
Moan....	3·83	·	55

ROTATION NUMBER.

816

DATE.	DAILY RATE. Gaining	DAILY RATE. Losing.	Mean Temperature Fah.
1872.	SECS.	SECS.	DEGS.
April 29	2·4	·	85
,, ... 30	2·2	·	85
May 1	1·9	·	85
,, ... 2	2·1	·	86
,, ... 3	2·2	·	85
,, ... 4	2·5	·	84
Mean....	2·22	·	85
May 6	0·0	·	70
,, ... 7	0·4	·	70
,, ... 8	0·1	·	70
,, ... 9	0·0	·	70
,, ... 10	0·3	·	71
,, ... 11	0·3	·	71
Mean....	0·18	·	70
May 13	·	3·7	55
,, ... 14	·	3·9	55
,, ... 15	·	3·2	55
,, ... 16	·	3·4	55
,, ... 17	·	3·4	55
,, ... 18	·	3·6	55
Mean....	·	3·53	55
May 20	0·3	·	70
,, ... 21	0·1	·	71
,, ... 22	0·1	·	69
,, ... 23	·	0·1	70
,, ... 24	0·2	·	70
,, ... 25	0·3	·	70
Mean....	0·15	·	70
May 27	2·2	·	85
,, ... 28	3·1	·	85
,, ... 29	3·1	·	85
,, ... 30	3·1	·	85
,, ... 31	2·6	·	84
June 1	3·0	·	86
Mean....	2·85	·	85

ROTATION NUMBER.

863

DATE.	DAILY RATE. Gaining	DAILY RATE. Losing.	Mean Temperature Fah.
1872.	SECS.	SECS.	DEGS.
June 24	·	0·5	86
,, ... 25	·	0·2	85
,, ... 26	·	0·1	85
,, ... 27	·	0·5	84
,, ... 28	·	0·4	85
,, ... 29	·	0·3	86
Mean....	·	0·33	85
July 1	0·1	·	70
,, ... 2	0·2	·	71
,, ... 3	0·3	·	71
,, ... 4	0·2	·	70
,, ... 5	0·2	·	69
,, ... 6	0·1	·	70
Mean....	0·18	·	·70
July 8	·	0·6	55
,, ... 9	·	0·4	55
,, ... 10	·	0·5	55
,, ... 11	·	0·4	55
,, ... 12	·	0·2	55
,, ... 13	·	0·5	56
Mean....	·	0·43	55
July 15	0·4	·	70
,, ... 16	0·4	·	70
,, ... 17	0·3	·	70
,, ... 18	0·4	·	71
,, ... 19	0·3	·	71
,, ... 20	0·3	·	69
Mean....	0·35	·	70
July 22	·	0·2	85
,, ... 23	·	0·1	87
,, ... 24	·	0·2	85
,, ... 25	·	0·7	85
,, ... 26	·	0·6	86
,, ... 27	·	0·h	86
Mean....	·	0·37	85

At the Royal Observatory at Greenwich, and at the Liverpool Observatory, chronometers are also said to be rated, but the object of rating them at these establishments is to test the instruments, as regards their quality for steadiness of rate, from day to day, and from week to week, and to show the variations of rate caused by change of temperature. The difficulty in predicting the rate for a voyage arises from the imperfect state of the instrument; and by a well-arranged and carefully conducted test, these imperfections may be so exhibited as to enable the mariner to avoid the danger which must frequently follow from the neglect of such precautions. The Greenwich mean time is now so easily obtained in most seaports, that there can be no difficulty in ascertaining the daily gain or loss of a chronometer, if the rate so found could be depended on. The communication of time to the Port of Liverpool, by the firing of the gun which is placed on the Morpeth Dock Pier Head, has been so successful that the difference between the flash of the gun and 1 p.m. Greenwich mean time has not, on any occasion during the past year, been such as could lead to an error in a ship's longitude to the extent of the width of the Mersey opposite the point on which the gun is placed, and by observing the flash of the gun on two occasions at an interval of a few days, the rate of a chronometer may be obtained with sufficient accuracy for most practical purposes. The rate so obtained might, however, differ very much from the rate at sea, if the temperature in which the rate was obtained in port differed much from that to which the instrument was exposed on the voyage.

Imperfect thermal adjustment is a defect so well-known, that during the past thirty years the attempts made to improve the quality of marine timekeepers have been mainly confined to the compensation balance. Balances have, without doubt, been made to compensate for change of elasticity in the spring throughout long ranges of temperature, but there is evidently some objection to their general adoption for the merchant navy. It is possible that the thinness of the laminæ, and peculiarity in the construction of balances which are made with the view of removing the defect above named, may render them less permanent in their action, and more liable to injury in the hands of a less skilful mechanic than the original maker; but however this may be, the ordinary balance seems to be almost universally used in the merchant navy. At the New Observatory chronometers are tried in three definite temperatures, with the view of showing the amount of change in their rates due to error of thermal adjustment, and more than one thousand marine timekeepers have now been tested in 55°, 70°, and 85° of Fah. From a careful examination of the records of these tests there appears to be a definite temperature peculiar to each chronometer in which the instrument goes faster than in any other temperature, and as the number of degrees above or below this temperature of maximum gaining rate increase, the chronometer loses in a rapidly increasing ratio. If we assume this law of variation to be that the change of rate is directly as the square of number of the degrees from the maximum gaining rate, the rates calculated on that assumption are found sensibly to agree with those obtained from observation; therefore, if we have the rate from observation for each of three definite temperatures, as given in my last two reports, we can find, by computation, the correction for error of thermal adjustment due to any other temperature. In order to do this it is necessary to find—

T . . the temperature in which the chronometer has its maximum gaining rate,

R . . the rate at the temperature T, and

C . . the factor, or constant number, which multiplied by the square of any given number of degrees from T shows the amount of loss for that number of degs.

The following examples show the method of calculating C, T, and R from the observed rates in 55°, 70°, and 85°, taken from Table 1 in this report.

Let N = any number of degrees from T, then the Rate at $T + N = R + C \times N^2$.

Required the Rate of No. 727 at 40°

Here $N = 29{\cdot}31$ and $N^2 = 859{\cdot}08$,

Therefore the Rate at 40° $= -\ 1{\cdot}88 + (-\ 0{\cdot}00509 \times 859{\cdot}08 = -\ 6{\cdot}25$.

The values of C and T remain the same for long periods; as a rule, they do not sensibly change so long as the adjustments are not altered, and the instrument remains in good condition; but R is more changeable, and should be redetermined on all favourable occasions. To find the change in R the rate must be first carefully found in some definite temperature. Suppose, for example, that at some subsequent time the rate of No. 727 was found to be —2·13, instead of —3·13, in 85°, then the rate at T would be —0·88, instead of —1·88; but it might not be convenient to obtain the rate in either of the temperatures in which the rates are given in the test, and then it may be found as follows: Suppose the rate has been found to be —1·55 in 81·5, then the rate must be computed for 81·5, on the assumption that R has not changed, and the difference between the rate observed and the rate computed will be the correction to be applied to R.

EXAMPLE 1.—No. 727.

s.

Rate in 55° = − 2·92 - - - r

r − r′ = − 1·04 - - - d

„ 70 = − 1·88 - - - r′

r′ − r″ = + 1·25 - - - d′

„ 85 = − 3·13 - - - r″

d − d′ = − 2·29

d + d′ = + 0·21

$$C = \frac{2(d - d')}{30^2} = \frac{-4\cdot58}{900} = -0\cdot00509$$

$$T - 70 = \frac{d + d'}{C \times 60} = \frac{+0\cdot2}{-0\cdot3054} = -0\cdot69$$

$$T = 70 - 0\cdot69 = 69\cdot31$$

$$R = r' - (T - 70)\frac{d + d'}{60} = -1\cdot88 + 0\cdot69 \times 0\cdot0035 = -1\cdot878$$

EXAMPLE 2.—No. 731.

s.

Rate in 55° = + 3·79 - - - r

r − r′ = + 2·65 - - - d

„ 70 = − 1·14 - - - r′

r′ − r″ = + 3·39 - - - d′

„ 85 = − 2·25 - - - r″

d − d′ = − 0·74

d + d′ = + 6·04

$$C = \frac{2(d - d')}{30^2} = \frac{-1\cdot48}{900} = -0\cdot00164$$

$$T - 70 = \frac{d + d'}{C \times 60} = \frac{+6\cdot04}{-0\cdot0984} = -61\cdot38$$

$$T = 70 - 61\cdot38 = 8\cdot62$$

$$R = r' - (T - 70)\frac{d + d'}{60} = +1\cdot14 + 61\cdot38 \times 0\cdot1007 = +7\cdot32$$

EXAMPLE 3.—No. 816.

s.

Rate in 55° = − 3·53 - - - r

r − r′ = − 3·70 - - - d

„ 70 = + 0·17 - - - r′

r′ − r″ = − 2·37 - - - d′

„ 85 = + 2·54 - - - r″

d − d′ = − 1·33

d + d′ = − 6·07

$$C = \frac{2(d + d')}{30^2} = \frac{-2\cdot66}{900} = -0\cdot00296$$

$$T - 70 = \frac{d + d'}{C \times 60} = \frac{-6\cdot07}{-0\cdot1776} = +34\cdot18$$

$$T = 70 + 34\cdot18 = 104\cdot18$$

$$R = r' - (T - 70)\frac{d + d'}{60} = +0\cdot17 + 34\cdot18 \times 0\cdot1012 = +3\cdot63$$

FROM THE PRECEDING EXAMPLES.

	MEAN DAILY RATE in 55°	in 70°	in 85°	C.	T.	R.
	s.	s.	s.			
No. 727	— 2·92	— 1·88	— 3·13	— 0·00509	69·31	— 1·88
„ 731	+ 3·79	+ 1·14	— 2·25	— 0·00164	8·62	+ 7·32
„ 816	— 3·53	+ 0·17	+ 2·54	— 0·00296	104·18	+ 3·63

The computation is as follows: 8·15 — 69·3 or $N = 12{\cdot}2$ and $12{\cdot}2^2 = 148{\cdot}84$;

Therefore, the rate at $81{\cdot}5 = -1{\cdot}88 + (-0{\cdot}00509 \times 148{\cdot}84 = -2{\cdot}64$.

Observed rate in $81{\cdot}5 = -1{\cdot}55$. Computed rate in $81{\cdot}5 = -2{\cdot}64$. The losing rate at T must therefore be diminished by 1·09, making the newly found $R = -0{\cdot}79$, instead of $-1{\cdot}88$.

For any chronometer which has been allowed to remain at the Observatory for a period of five weeks, the certificate of test issued with the instrument contains the necessary data for calculating the correction due to imperfect thermal adjustment.

Letters to the Editor.

All letters to be addressed to the Editor, at the Institute, 35, Northampton Square, E.C.

SIR,—When I wrote the letter you published in the October number of the *Horological Journal*, it was not my wish to open any discussion on the merits of going barrel watches. I only wished to mention some facts, as I happened to have a going barrel watch with the report from an Observatory, which is, at least so far as I know, as much to be relied upon as any other Observatory.

"A Member of the Horological Institute" has, however, answered my letter in such a way that I, though reluctantly, will ask you kindly to allow me a little space in your *Journal*.

The "Member" makes me say that the fusee is a useless contrivance, only calculated to deceive the ignorant amongst watchmakers. I have not said so. I did not mention watchmakers at all. I said "the great mass of people who are entirely ignorant of watches and watchmaking."

I came to think so, because I have seen in many shops where they sell watches, that going barrel watches are marked as having maintaining power. I do not know how going barrel watches can be made without maintaining power; therefore, what is the object in marking the watches like that, unless it is to make people believe that if the watch has maintaining power it must also have a fusee, and that the same watch would, as a matter of course, be better for having a fusee. This I think is a mistake.

The "Member of the Horological Institute" asks "if Mr. Lange really believes that a main spring, which makes a watch fall off in the vibration a quarter of a turn when nearly down—(I suppose that means when the watch has gone fully 24 hours),—can make a watch go so well as a watch with a fusee and a tapered main spring with the least amount of friction and pulling, with equal force on the train all through, all things in both watches being alike."

No; I do not think so.

But the above has really nothing to do with the question, and is only calculated to mislead those that do not understand watchmaking. I never saw a going barrel watch, not even a common horizontal one, fall off a quarter of a turn.

How many fusee watches have a tapered main spring which pulls with equal force all through the train; and supposing they have when new, where do the greatest number of watch repairers get tapered main springs that fit the old fusee so as to pull with equal force all through?

Does "the Member" really believe that when a new main spring is put into an ordinary fusee watch, that the jobber takes any trouble to know if the main spring is tapered or not? To my certain knowledge very few jobbers use the adjusting rod at all. That being the case, what is the use to ask me such a question? It proves nothing.

The "Member" finds fault because I support my argument by a watch not of my own make. What does that signify? If the watch had fallen down from the moon it would have been the same thing. The fact is simply this, I had a going barrel watch of an ordinary size, which made an average variation in about two months of $\frac{8}{10}$ of a second, and makes no difference between hanging and lying. If I had written the letter for the sake of advertisement, I should have mentioned a watch of my own making.

Only one remark more. Why do not gentlemen put their names to the letters they publish in the *Journal*? Are they afraid to acknowledge their own opinions? I can understand young men who want information not wishing to let us know who they are; but men who speak with authority should not hide their names.

CHRISTIAN LANGE.

99, Strand.

SIR,—With reference to Mr. Thos. Nickall's letter in your last issue, permit me to state that in this neighbourhood is a very well made turret clock bearing the following inscription on the inside dial :—"Charles Penton, Upper Moorfields, London, 1773." Will not this answer the above-named correspondent's query?—Yours, &c.,

JAMES PADBURY.

Bishop's Waltham.

Sir,—Should a prize be given at the exhibition of work for the best specimen of gilding, I sincerely hope that the judges in awarding such prize, will be influenced more by the hardness of the brass-work that has undergone the process, than by the beauty of finish in the gilding itself.

It is a notorious fact that the greater portion of the watches made in this country at the present day are, if not spoiled, at any rate greatly deteriorated by gilding; notwithstanding which we go on year after year on the same system. Although the plates are made of hard-rolled brass, well hammered stoppings are put in, to secure the highest degree of hardness for the pivot holes, after which, by a strange inconsistency, the whole is put into the fire and annealed, for the mere sake of improving the appearance of the gilding! The matter is on the face of it so very absurd that I sometimes find a difficulty in making my customers believe it, when explaining the reason for my work not being gilt. I have frequently mentioned the subject to members of the trade, but, while acknowledging the fact, they usually pass it by as a trifling matter unworthy of their consideration. Some years ago, however, a Coventry manufacturer called on me offering some low-priced watches for sale, and, on my remarking that the work, though very plain, would be sound but for being spoiled by bad gilding, asking him at the same time why he did not machine-spot or otherwise finish the plates, and polish the barrel and wheels, he favoured me with the following remarks:—Firstly: Jewellers and others that he served would not like the appearance of the movement so well as though gilt, and consequently the sale would be interfered with.

Secondly: That watches lasted too long as it was, and that it was undesirable to do anything to make them last longer.

Thirdly, and lastly: That if steady-pins did get loose, screws overturn, great wheel-teeth get bent, pivot holes elongate, barrels get out of shape by the breaking of mainsprings, &c., &c., so much the better for myself and others who undertook the repairing of watches. I am afraid that this represents but too truly the feeling of many others.

Movements may, if care is exercised, be water-gilt without any appreciable softening of the brass; but this is too expensive for the cheaper kind of work. Machine spotting gives a very ornamental finish to the plates; but, so far as I know, there are only one or two in Clerkenwell who undertake it, and their charges are high. But that it may be done at a small expense is evident from the fact that many of the lowest-priced Geneva watches are machine-spotted. I have been in the habit of finishing the plates of my cheaper watches with charcoal and oil, giving them a curl with a piece of charcoal cut up to a blunt point, and slightly bevelling and burnishing the edge of the upper plate. This makes a neat finish, and the oil being worked into the pores of the brass, protects it from tarnish to a considerable extent; so that when watches come into my hands, after an interval of two years, for cleaning, the plates are scarcely discoloured. Still, I should be glad to hear of any better method; and hope that at any future exhibition of work a prize will be offered for the best mode of finishing watch plates without gilding.

W. M. DAWES.

160, Upper-street, Islington.

Sir,—Thinking it may be an object of interest to many of your members, and desiring some information myself respecting it, I have deposited for a few days in your museum the broken escapement of an old chronometer I possess which bears upon the dial the name of "Cummins, London." All to whom I have shown the escapement declare they have never seen the like. I am thinking of replacing it with a modern one, at the same time I should be reluctant to do so if it posseses any historical value.—Yours, &c.,

J. B. DYER.

Sir,—A late correspondence by "Clerkenwell," Aug. 13, speaks of an inconvenience in keyless watches, and, in order to avoid it, wishes to introduce an up and down indicator into the going barrel movement. This, however, would be rather difficult, since the barrel arbor is stationary when the watch is going, and rotating when it is wound. At any rate, it would be an exceedingly complicated matter, and a source of other irregularities, or, if made in the simple way quoted of an old Brequet watch, it would attain the purpose at a considerable sacrifice of height of the watch.

But, on close investigation, it seems that a very simple remedy may obviate the difficulty in question, which arises, if one of the teeth of the wheel on the barrel arbor by an excess of winding strain, is forced beyond the click and held in that position. If that wheel is of large diameter and the teeth in it are small, and especially if the stop-work is at one end of the arbor and the winding wheel at the other, a certain degree of tension is exerted on the arbor and acts to increase the motive power of the mainspring, which, at the same

moment, is at its maximum. This often causes a violent banking of the watch during several minutes, much to the discredit of the watch, which, when carefully treated, is perhaps an excellent timekeeper. Mr. A. Lange has found out a very simple remedy against this extra strain, by allowing the click a little back motion, which releases the strain immediately after it has been created.

It is true that this arrangement realises but one of the desiderata of "Clerkenwell," but I think this one the more important one of the two, because it prevents any injury to timekeeping by excess of winding strain, and the convenience of verifying on the dial whether the watch is wound up or not, will most likely not pay by itself the expense of an up and down indicator.

M. GROSSMANN.

Glashütte.

Jottings by W. G. Schoof.

An advantage of using a cylinder short in the acting part, so that the escape wheel tooth only just frees the upper pivot properly, is that the oil being attracted to the upper pivot or plug, each tooth as it passes into the cylinder is—as it were—immersed in an oil box. Whereas with a longer cylinder the oil as before being attracted to the corner, is drawn *away* from the teeth of the wheel.

Many may not be aware that French pendules may be brought to time in a few minutes by counting the beats of the pendulum. The trains of these clocks being always arranged so that the escape wheel makes two revolutions per minute, or four vibrations for each tooth per minute, it is evident that with a regulator or seconds watch handy errors can be ascertained by observing whether the number of beats the pendulum makes per minute equals four times the number of teeth in the escape wheel. The above does not apply to French drum clocks.

Pivots and acting surfaces of watchwork should not be polished with diamantine. Whether the diamantine gets mechanically incorporated with the steel, or in what way the effect is brought about I cannot say, but I have observed that with the most careful cleaning the holes in which surfaces so polished work are very quickly worn away, and for polishing wearing surfaces diamantine must be abandoned for red stuff.

To Correspondents.

AN UNBELIEVER.—*The moveable weights mentioned in our description of the Westminster Clock in the November number of the* JOURNAL *may have something to do with the discrepancies in the weight of the pendulum as given by various authorities. Another point is that some mention the weight of the bob alone, while others in the weight given, indicate the whole pendulum.*

Can any of your readers tell me in what respect the hook in the barrel is better than the square steel hook in the main spring.—P. K.

G. V. S.—*The promised remarks on irregularities in the timekeeping of clocks are not yet to hand.*

Can any correspondent inform me if magnetism can be got out of steel, otherwise than by heat. That heat will do it I have proved, as with a magnetised compensation balance that recently came under my notice, I found that by placing the balance on a heated ferrule (having a large hole in the centre to prevent the staff discolouring) and suddenly blueing it, the magnetism had entirely disappeared. The sudden heat, however, had put the balance so much out of truth that it was a matter of some difficulty to get it true again, in addition to which the blue had to be left on. I am told that magnetism can be more effectually and easily removed from any piece of steel with a magnet. If this is so, can any correspondent tell me the exact means to adopt, especially with a circular piece like a finished compensation balance?—JUNIOR.

HOW TO MAKE MONEY BY PATENTS (by Charles Barlow).—Third edition: Marlborough and Company, Warwick-lane. A well-written book, containing much information useful to would-be patentees. Mr. Barlow draws some charming pictures of men who have benefited the nation, and obtained wealth and position for themselves, by their inventions, and although the majority of those who are unfortunate enough to invent anything cannot hope for such happiness, they may find plenty in the book before them to repay a careful perusal.

THE annual festival of the Clock and Watch Makers' Asylum was held on Tuesday, November 11th, at the Cannon Street Hotel, Mr. Samuel Jackson, chairman of committee presiding. We were not favoured with an invitation, and are therefore unable to give any report of the proceedings.

British Horological Institute.

DIARY OF MEETINGS FOR DEC., 1873.

DAY.	DATE	TIME.	BUSINESS.
Monday	1	8.0	Technical Class.
Tuesday	2	7.30	Journal Committee.
Tuesday	2	8.30	Council.
Thursday	4	8.0	Technical Class.
Monday	8	8.0	Ditto.
Wednesday	10	8.0	Lecture.
Thursday	11	8 0	Technical Class.
Monday	15	8.0	Ditto.
Thursday	18	8.0	Ditto.
Monday	22	8.0	Ditto.
Thursday	25	8.0	Ditto.
Monday	29	8.0	Ditto.

MEAN TIME OF THE SUN'S SEMIDIAMETER PASSING THE MERIDIAN OF GREENWICH, AND EQUATION OF TIME TABLE.—December, 1873.

Day of the Month.	Day of the Month	Mean time of the Sun's Semidiameter passing the Meridian.		Equation of Time *to be subt. from* / *added to* Apparent Time.		Difference of One Hour
		S.	M.	M.	S.	S.
Mon	1	1	10·1	10	39·6	0·948
Tues	2	1	10·2	10	16·6	0·973
Wed	3	1	10·3	9	52·9	0·998
Thurs ..	4	1	10·4	9	28·7	1·022
Fri	5	1	10·5	9	3·9	1·045
Sat	6	1	10·5	8	38·5	1·067
Sun	7	1	10·6	8	12·6	1·089
Mon	8	1	10·7	7	46·2	1·109
Tues	9	1	10·7	7	19·4	1·128
Wed	10	1	10·8	6	52·1	1·146
Thurs ..	11	1	10·8	6	24·4	1·163
Fri	12	1	10·9	5	56·3	1·178
Sat	13	1	10·9	5	27·9	1·192
Sun	14	1	11·0	4	59·1	1·205
Mon	15	1	11·0	4	30·0	1·217
Tues	16	1	11·0	4	0·7	1·227
Wed	17	1	11·0	3	31·1	1·235
Thurs ..	18	1	11·1	3	1·4	1·242
Fri	19	1	11·1	2	31·5	1·248
Sat	20	1	11·1	2	1·5	1·251
Sun	21	1	11·1	1	31·5	1·253
Mon	22	1	11·1	1	1·4	1·253
Tues	23	1	11·1	0	31·3	1·252
Wed	24	1	11·1	0	1·3	1·249
Thurs ..	25	1	11·1	0	28·7	1·245
Fri	26	1	11·1	0	58·5	1·239
Sat	27	1	11·0	1	28·1	1·231
Sun	28	1	11·0	1	57·6	1·222
Mon	29	1	11·0	2	26·8	1·213
Tues	30	1	11·0	2	55·8	1·202
Wed	31	1	10·9	2	24·5	1·190

NORTH POLAR DISTANCE AND DECLINATION OF CERTAIN STARS, AND TIMES AT WHICH THEY ARE ON THE MERIDIAN OF GREENWICH.—December, 1873.

Star's Name and Magnitude.	Day of Month	N. P. D. / Declination, At Meridian Passage			Sidereal Time / Mean Time At Meridian Passage.		
		°	′	″	H.	M.	S.
β Tauri	2	61	29	59·4	5	18	20·0
		N 28	30	0·6	12	30	41·3
Mag. 2.	12	61	29	59·0	5	18	20·1
		N 28	30	1·0	11	51	22·4
	22	61	29	58·5	5	18	20·2
		N 28	30	1·5	11	12	3·4
β Orionis (*Rigel*)	7	98	20	50·6	5	8	29·5
		S 8	20	50·6	12	1	12·9
Mag. 1.	17	98	20	52·3	5	8	29·6
		S 8	20	52·3	11	21	53·9
	27	98	20	53·9	5	8	29·6
		S 8	20	53·9	10	42	34·8
α Tauri (*Aldebaran*)	2	73	44	39·7	4	28	41·8
		N 16	15	20·3	11	41	11·3
Mag. 1.	12	73	44	39·9	4	28	41·9
		N 16	15	20·1	11	1	52·2
	22	73	44	40·0	4	28	41·9
		N 16	15	20·0	10	22	33·2
β Aretis	7	69	48	27·6	1	47	40·6
		N 20	11	32·4	8	40	57·0
Mag. 3.	17	69	48	27·6	1	47	40·6
		N 20	11	32·4	8	1	37·0
	27	69	48	27·7	1	47	40·5
		N 20	11	32·3	7	22	18·5
θ Ceti	2	98	50	6·8	1	17	43·4
		S 8	50	6·8	8	30	44·2
Mag. 3.	12	98	50	7.8	1	17	43·3
		S 8	50	7·8	7	51	25·0
	22	98	50	8·7	1	17	43·2
		S 8	50	8·7	7	12	5·8
β Ceti	7	108	40	52·5	0	37	15·5
		S 18	40	52·5	7	30	43·4
Mag. 2.	17	108	40	53·5	0	37	15·4
		S 18	40	53·5	6	51	24·2
	27	108	40	54·2	0	37	15·3
		S 18	40	54·2	6	12	4·9

British Horological Institute.

The Manufacture of Watches as carried on at the Works of the National Watch Company.—Elgin, Illinois, U.S.A.

A Lecture delivered at the Institute, on Wednesday, Dec. 10th, 1873,

BY MR. T. PERKINS.

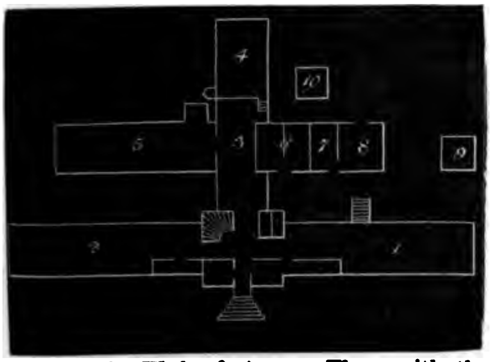
MR. JACKSON (Treasurer) presiding.

THE CHAIRMAN, after apologising for the inadequate size of the rooms, introduced Mr. Perkins, from whose practical experience of the watch factories of the United States, he anticipated a lecture that would repay the most careful attention of the members present.

The LECTURER, having briefly sketched the usual mode of initiating a watch factory, continued as follows :—

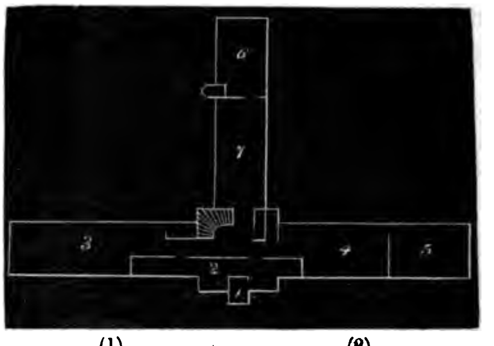
"The gentlemen employed in its initiation brought with them a staff of skilled workmen, who were at once set to work building machinery in a room in a foundry fitted up for the occasion. The next thing to be done was to erect a factory building. This must be accomplished, not only with a view to the early needs of the company, but also in such a manner that while space may be economised at first, it may also be used advantageously when the exigencies of trade should call for an extension and an increase in the labour-roll and power of production. Such a plan was adopted as would enable the corporation to build commodiously for the production of forty movements per diem, while means of extension were provided, looking from and to the manufacture of 400 to 500 movements per day and the employment of 1,000 operatives. Appended are plans of the ground and first

(Fig. 1.)



floors of the Elgin factory. These with the indices attached will perhaps prove of use in following the growth of the watch, as it is developed from the raw brass and steel into a thing of beauty and of life. The building is of yellow brick with sills and lintels of cut freestone. It is commodious and well arranged, and only lacks a perfect system of ventilation to make it a model factory.

(Fig. 2.)



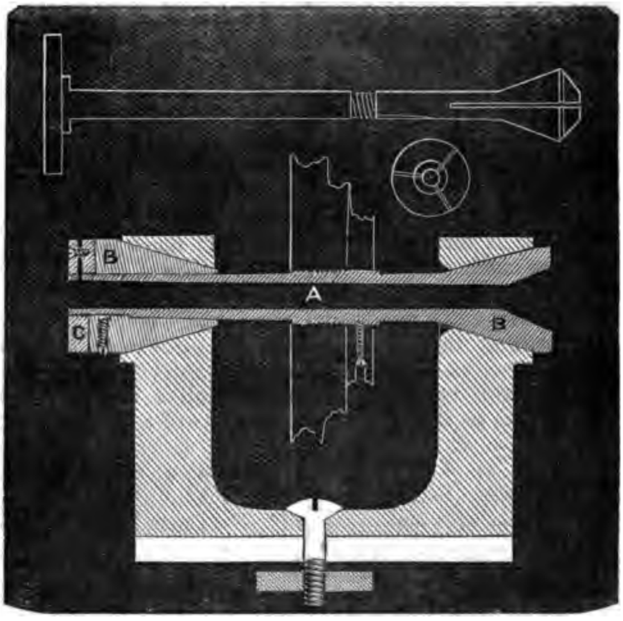
(1)	(2)
1. Machine Shop	1. Managing Office
2. Train do.	2. Material do.
3. Cloak Room	3. Jewellery Room
4. Gilding do.	4. Flat Stee & Screw do.
5. Dial do.	5. 'Scapement do.
6. Engine do.	6. Balance do.
7. Smithy do.	7. Setting up do.
8. Press do.	
9. Fire Proof do.	
10. Smoke Stack	

This lack is one which is in truth of more importance to employers than appears on the surface. Not only is the ill effect visible in the pale cheeks and ruined constitutions of those who are penned up in the close overheated rooms, to breathe for ten hours in each day their fellow prisoners' exhalations; but were the rooms properly ventilated the result would soon be made manifest in the greater average of hours made monthly by each employé and of course in the increase of profit to the company. It will be seen from the diagrams that the buildings assume the form of a block-letter T, with the additional necessary buildings in the angles and to the

rear. It will be found that the form adopted permits an extension of a central block and two wings at the rear to match the front, while if it be then found necessary to use still further room, the ends of the respective wings may be joined, giving four additional rooms of 100 feet each, and making a working capacity in the whole factory for at least 1,500 employés. Having now made ourselves acquainted with the building and its interior arrangements, let us people it with the workmen whom we left in an out workshop. We shall find that we bring into operation the machine, carpenters, and pattern room, the smithy, and the draughtman's office. The latter is a busy, quiet place at all times in the life of the factory, for there is the chief mechanical brain always at work planning some new machine, which shall perform some little operation somewhat better or somewhat quicker than did the old tool; but in the infancy of the institution the brain and pen in that little room are busy indeed, for thence proceed all the working drawings of all the machines and tools, general and special, to be used in the contemplated manufacture. Pass we with this lot of drawings from the office to the room where are prepared the patterns for the coming machinery. Skilful workers in wood are these pattern makers, and they need be. As a boy I remember standing and gazing in wonderment at the strange shapes which were produced in the casting shops at the railway works in our town. But of all the odd shapes for castings ever produced, commend me to the pattern room of a watch factory. Patterns and castings prepared, let us betake ourselves to the machine shop. This place we need scarcely describe any further than to state that as far as the machine shop of a gun factory is beyond that of any ordinary manufacture, so far is the machine room of a watch factory beyond that of the most complete gun factory extant. And this superiority is not only in number and arrangement of tools, but also in the delicacy and finish of the machinery employed. Here are to be found lathes which would be stigmatized as toys in any ordinary metal works, and some machines are here also, a speciality among which we may mention the parallel grinders, by which are reduced to exact size and truth the hardened spindles and bearings of the various tools. It will not be necessary to detail the varied tools to be found in this room, comprising, as they do, large and small planers, engine and speed lathes, drilling and milling machines, taps, dies, drills, and countersinks. All these are here, presided over by workmen who are leaders in the ranks of practical mechanism. These take the working drawings, and by dint of planing and turning and milling and filing they convert the rough-looking casting into the beautifully-finished tool which we shall soon meet with in some other department. As the draughtsman's office is the brain of the factory, so the machine department is the heart. Were it allowed to deteriorate in any way, the whole establishment must decline. In fact, it is not too much to say that the success of the factory depends upon the efficiency of this department. Before we review the manufacture proper let us look round the out-buildings and find what is being done there. Down over these steps and across the yard, and we find ourselves in the engine room. A beautiful piece of workmanship is the engine, and justly proud of his charge is the fat, jolly engineer, as he tells us that "she is 35 H.P., and in the six years that I have run her she has never gone back on me once." The ponderous fly weighs 3,000 lbs., and yet, with its connected shafting, it is so delicately poised and adjusted that when at rest it can be started and turned easily by a child. And so, minute after minute, hour upon hour, day in and day out, this engine throbs on, turning some 3,000 feet of shafting on which are pullies by the thousand and belting by the mile. The shafting is run at a uniform speed of 218 revolutions per minute. In the next room west is the smithy. Here a smith and a striker are kept busy in forging the varied sizes and shapes, in steel and iron, necessary for the spindles and taps, bolts and nuts, cutters and reamers to be used in the machine shop. A perfect model of a smithy it is, too. The old bellows is nowhere to be found, but is replaced by a fan, tubes, and slide-valve, operated by a short lever which, as occasion requires, the workman depresses, and a draught is created which will speedily arouse a fire such as the most ardent smith may desire. A few rods to the rear are the gas works, the fireproof vault, the fire-engine house, and the carpenters' shop. In the latter building four men are kept constantly employed, doing the thousand and one things which are to be found in any place in which 600 hands are employed. Drawers have to be made, cupboards and benches and racks must be fitted, boxes and nests peculiar to the trade must be provided to receive the pieces and movements during the manufacturing processes. Polishing blocks and slips must be made and kept in order, and machines and treadles have to be set up day by day. Returning across the yard, we will enter the first manufacturing room proper—the press room. This is without doubt the initial point of the watch movement. Here we find presses, punches, and

which are used in the formation of s to be converted hereafter into finished The press is such as may be found in ıachine shop, but the punches and dies imply marvellous. Some are plain es, and through dies, such as are used paring the blanks for plates, pottances, s, cover-bridges, cocks, hour and e wheels, steel work and several small inor objects. The triumph of the room ched in the punch and die used to form ossed wheel blank. The old method was rk out the arms and put on a solid wheel size desired, and then with drill and remove the superfluous metal. Now it r click! click! and the blanks are ready d at the rate of several thousand per Briefly, the manufacture of the new of article is this: The brass is rolled and to strips of an uniform thickness and . The die is formed of hardened steel, the exact size and shape of the wheel ed; while the punch is fitted so exactly that when it descends and presses through the brass to a level with the face of the die it returns carrying the blank wheel on its outer circumference. Before it ascends very far, however, a little five-fingered hand reaches down the interior and exterior of the punch and gently saying "Get thee gone, friend," quietly forces the blank off, and it drops into a receiver under, and is ready to have teeth cut on its outer circumference. The manner in which the blanks for dials are made is curious, requiring three separate subjections to the press, and coming out finally with the recesses for the dial feet made and the hour and seconds' holes prepared for the reception of the enamel. We will now take some of the plate punchings, and, passing through the basement, we will enter the plate room. Before we commence to follow the growth of the movement here we will notice the make of the principal tools around us. The old combination or the spring chuck lathe is a wonderful invention. We give a diagram in

(Fig. 3.)



ı showing the principles involved in it. l be seen that it consists of a hollow l spindle A, which runs in taper gs B B. The back taper is a separate from the hollow spindle, but is seto it by a screw. The rear end of ıollow spindle is tapped to receive k nut C, with which the end shake be taken up. The front end of the r spindle is bevelled to receive a chuck, which passes down its inside s drawn to its bending position by an inside bolt, operated from the back of the spindle. A plan of the chuck, and a side view of the chuck and bolt are given. This lathe is very much used for many operations in this department, but it was found not reliable enough when a number of different articles were to be turned with an exact regard to thickness; and so the necessity arose for an invention to correct this fault. The ingenuity of the machinist rose equal to the occasion, with the three-bearing lathe. In the tool we have just described it will be

remembered the chuck was drawn down to the bevelled bed of the hollow spindle. It is easy for us to see that a little more or less of a turn of the bending bolt would place the face of the chuck a little nearer to, or further from, any fixed cutter before it. So, it was thought, the only method to be used was one in which the chuck face should be fixed. This was done by adding another bearing, making the hollow spindle a fixture in relation to the revolving parts, and screwing the chuck firmly down to it, enveloping it with a cylinder whose bevelled face could be advanced or receded to open or close the jaws of the spring chuck, and thus clip or release the work, as desired. I may say that since writing this I have seen the drawing of a two-bearing lathe which has every advantage of the three-bearing lathe, and can be built for about one-half the sum the latter costs. It is constructed by making a hollow spindle, on which is mounted the pulley capable of advance and retiring motion, so as to close and open the chuck, which is secured in the same manner as in the ordinary spring chuck lathe. The holes for the dial feet are made by a punch, very nicely adjusted, as great care is required, these holes forming the fixed position from which all the other work in the watch is obtained. In all the future chuck work, whether for depths or sinks, the pillar plate is first slid over three pins, which exactly fit the dial feet holes, and then is clipped and held by wedge dogs while the work is being done. The chuck as fitted is termed a quill chuck, from the peculiar mode of revolving the head, the spindle being surrounded by a skin which is held by a clamp half tail-stock on the lathe bed. We will go to the largest of these lathes and see the workman take the round flat punching, and, after using several different chucks, return it to us with a lot of little sinks cut in it for ratchet and motion work and centre wheel. Passed to another workman, the plate is placed in a curious lathe, with an eccentric head, by which he is enabled to drill, with unerring accuracy, the holes on which the pillars are to be placed. We take our plate to the next lathe, whereon a workman places a length of brass wire. Immediately a cutter is advanced, which turns and shapes and cuts to the right length. A die is run up, and the end of the wire is tapped. It is then run into the plate, broken off, and we have a pillar. Three more are fitted in the same manner, which are then drilled down the centre and tapped, and the plate is ready to receive the top plate, bridge cock, and pottance, which workmen have meantime been shaping and drilling and turning and steady pinning. These parts, all gathered into a recessed box, are passed to a man, who sees that each set is properly made and fitted, and will sit in its proper position. The plates are now ready to receive the engraving, and while the operatives are engaged in stamping or cutting the various marks which are hereafter to be the warranty to purchasers, we will pass through the train department and find out how the wheels and pinions are manufactured. This department is the most important in the building, both in respect of number of peices manufactured and in number of employés engaged. It also is the best room in which to study the principle of the machinery used in the manufacture, inasmuch as there are few tools used in other departments which are not found in some form here. Out of thirteen departments this engages one-sixth of the whole number of employés. The parts made here are the barrel and arbor, centre wheel, staff and pinion, third and fourth wheel and pinion, scape pinion, pallet and balance staff, cannon and minute pinions, minute and hour wheel, set hands square, bevelled wheel and pinion main, intermediate and ratchet wheels for stem winding work, dial feet, jewel settings, and brass cups. This list calls for over six hundred different operations, and a monthly production for five thousand movements requires a supply of one hundred and ten thousand perfect and finished pieces from the department. It will, of course, be impossible to follow in detail the whole of these operations. It must suffice to give a general idea of the modes of work and the machinery employed. Let us follow, for instance, a third wheel and pinion. The wheel blank comes from the press room, as described above, ready for tooth cutting. The wheel cutting machine is very unlike the Swiss or English article. It consists of a live spindle, attached horizontally to a vertical traversing bed, which may be regulated, as regards distance, from the index quill, and which is traversed by means of a lever arm in connection with a rack and pinion. The quill is a steel spindle, the head of which is shaped true, to fit the spaces between the arms in the wheel blank, and to its base is attached an index and pawl. The live spindle is pierced in a right line with the diameter of the quill, to receive a cutter which is shaped to the space between two of the wheel teeth. The *modus operandi* is to place a stack of blanks upon the quill, and to secure them by a bolt. The live spindle with its cutter is revolved very rapidly, and by means of the lever arm is traversed, so as to make a vertical groove through the whole depth of the stack. The cutter is raised, and the stack moved, by means of the index and

pawl, the distance occupied by one tooth. A second cut is then made, and the operation is repeated until the whole circumference is filled with grooves. The stack removed, we find that each wheel is complete with its index number of perfect teeth. The next operation is drilling the whole in the centre for the hub, after which the wheels are sent to be stoned and gilt. This done, the next operation is threading the hole to receive the hub. Next is making the hub and inserting it in the wheel, which is effected in the following manner. A chuck lathe is prepared with a slide rest and two cutters, one of which is set to cut down the thread size, and the other to cut a nick almost through the brass wire of which the hub is to be made. This wire, about the size the hub is desired, is held in the chuck and revolved, when the first cutter is advanced and the thread size turned down, a die is applied and the thread cut, the second cutter is advanced and the nick cut, a holder with a wheel is brought up, and the rough hub is screwed into it and broken off. Next a chuck the size of the wheel is placed in the lathe, and a wheel is inserted, and held by its circumference while the hub is drilled, and one side is shaped as may be desired, by a ruby or sapphire cutter. The wheel is then reversed and the other side is shaped, and the hole which is to receive the pinion arbor is opened concentric with the circumference, and straightly tapering. This done, the wheel is ready to be mounted. Turn we now to the pinion making. The wire comes to the department, cut into pieces a little longer than the pinion will be. The first operation is pointing. To effect this a stop is set in a spring chuck, so that each piece may be pointed to the same length. The slide rest is fitted with two cutters, one to rough, and the other to finish the point, so as to produce an angle of 60 deg. The first cutter is advanced by the slide rest in the usual manner, to a stop. Returned to its place of rest, a spindle is advanced in a horizontal and right line, the cutter on its face being finely ground, so as to finish the bevelled point with a beautiful gray surface. That this point bevel should be perfect is very essential, as in all future work the holding in dead centres is more by the bevel than by its end. The other point is manipulated in the same manner, and the wire is ready for staff turning. This is done in an automatic lathe. The wire is hung in an ordinary small lathe, and is revolved by a wheel and dog. The cutter, unlike most lathes, is behind the work it is to turn, and the slide rest in which it is secured has a motion parallel to the line of the work, and is projected by an endless screw gearing. By means of a cam the length of the turning can be regulated, and by means of a pair of expanding levers the taper desired is obtained. The cutter traverses the length desired, when, by means of a cam and tit, it is drawn back from contact with the work, and, being released, drops back into its normal position of rest. The operation then consists in a girl securing a dog to a pinion blank, inserting it between the dead centres, and starting the lathe. A turning is made the desired length, the cutter frees itself, returns, and stops, when the lathe is ready for the insertion of another piece. Such is the rapidity with which this operation can be done that an average worker can feed two thousand per day to the machine. The same routine is passed through with respect to all turnings of the staff, head size, and pivots. The operation described above was the first or rough turning of the staff, next the first turning of the short staff, then the finish turning of each, and the turning of the head size. The blank is now ready to have the leaves cut. The pinion cutter is but an adaptation of the milling tool. It consists of two spindles, to one of which is attached the index or spaced disc, which will correctly divide the pinion head. The blank is held between these spindles, not by the points, but by the staff. The mode of holding is described in

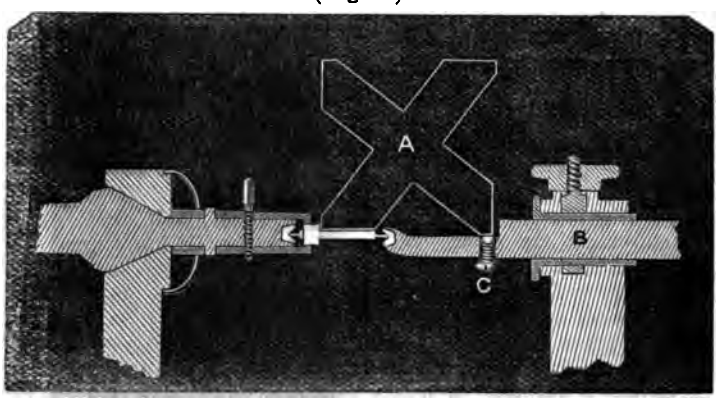
(Fig. 4.)

A a is a stout spindle, which with its taper centre is pierced throughout with a hole through which passes a driver c, used to force out the pinion from the taper after being cut. As said above, the pinion is held by the staff which is inserted into the hole in the arbour, it being bevelled a little to receive and hold it securely, so that it may be moved when the division plate which is attached to the rear end of A a is advanced. B is the back or tail spindle, the upper por-

tion of which is removed so as to allow the cutter D to pass freely beyond the pinion face. The cutter D is one of three which are supported by mandrels which in their turn are held in a cylinder arranged in such a manner that each mandrel may be brought consecutively into the place occupied by its predecessor. The cylinder is attached to a traversing bed whose course is in a right line with the centre of the pinion, lengthwise. The first cutter used is simply a saw, the second roughly shapes the leaf, while the third finishes it and smoothes it. The cutters are traversed the length of the pinion head by means of a lever arm and rack and pinion. It would be impossible here to give a full description of this work. The leaf cutting job is indeed one which calls forth as much of the true science of horology as any other in the watch factory, involving, as it does, all the intricate calculations for size of pitch circles and for the involute or epiclycoidal tooth.

The epiclycoidal curve is the one most favoured in America. In England I believe many incline to the use of the involute curve. Be that as it may; there have been a great many devices invented to obtain correctly the epicycloidal curve. The machine at the Elgin factory is ingenious, and consists in the absolute use of a pair of generating circles just ten times the size of the circles of the true wheel and pinion. After the leaves are cut the pinions are turned and are ready for hardening and tempering. Then comes the leaf polishing. In this operation the pinion is placed in a rocker rest upon which it is supported by its arbors. In a directly parallel line with the leaves is a reciprocating bar whose motion is obtained by a pitman, and to which is attached a polisher of grain tin whose edge is planed to fit the space between two of the pinion leaves. The polisher is charged with flour, emery, and oil, and set vibrating. The rocker rest with its superincumbent is then brought into pinion contact with the polisher. After a certain number of vibrations, the pinion is lowered and revolved one leaf and is again brought up into contact. This is repeated until the whole of the leaves are ground. The pinion is then cleansed, and the same process is gone through with red stuff, Vienna lime, and oil, in order to obtain a smooth surface and polish on the leaves. Next in order is the removal of the burr which was thrown up in the leaf cutting, after which the hollow is cut in the pinion face. The staff is now to be polished and the method may best be described by reference to

(Fig. 5.)

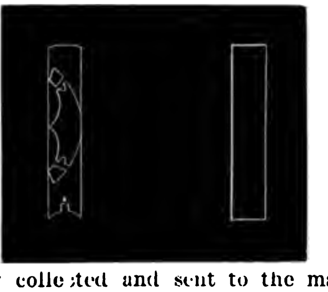


A is a wing polisher, made by soldering two flat pieces of steel together, This polisher has a reciprocatory motion at right angles with the axis of the pinion. This is obtained by its being swung in a frame attached to a pitman arrangement. The pinion is held in the dead centres of an ordinary lathe, and is rotated by a dog. It is of course necessary to secure the same degree of taper for all polishers in each kind of work. This is accomplished in this wise: The tail spindle B is filed away and a screw is fitted which has a ewel set in its face. As the sapphire cannot e hurt by the abrasion of the dust and time, spare edge of the spindle running on the stone will retain its parallellism for a considerable period. The other portions of the diagram show the method used for lightening spindles and also for revolving the pinions. The same principle is used in the polishing of the pivots, the only difference being the manner in whieh the pinion is held and revolved in the lathe head. The lathe is fitted with a spring pump centre, the face of which is jewelled with strict regard to truth, so as to take the back pivot. The live spindle is fitted with a shell chuck, the face of which is recessed so as to allow the protrusion of the pivot shoulder a short distance beyond its face. The mode of inserting is to withdraw

the pump centre a little, place the pivot to be polished from the inside through the face of the shell chuck and then allow the pump centre to bring the jewel in its face firm against the rear pivot, so that the whole may be kept securely in position while revolving. Then the reciprocating polisher may be used to finish with, and by its means a squarer and more beautiful shoulder may be obtained than by any hand process. We now require to face our pinion. If a very fine face is desired we use the small disc and drill bow and so go back to first principles. But for ordinary work we obtain a very good face by machinery —a better face, in fact, than is seen on good Swiss movements or in medium London work. The *modus operandi* is very simple, and consists of ordinary small spring chuck lathe, in which the pinion is clutched. In a line parallel with that of the pinion is a live spindle on which may be placed a cylinder disc of metal or ivory. The lathe and cylinder are revolved and the edge of the metal disc, previously charged with oil-stone dust, or flour-emery, and oil, is brought into contact with the pinion face. I should have stated that chuck and cylinder are run at different rates of speed and in opposite directions, a necessity, as the polish to be obtained can only be gained by a perfect crossing of all the abrasive lines. The face stoned flat, the roughing powder is thoroughly cleansed away, the ivory disc with Vienna lime and alcohol substituted, and the result is a fine dark polish, the only fault, with care, being a little rounding of the edges of the leaves. A final inspection is made, and all the perfect pinions are now ready to be pushed into the ready-prepared wheels. As I have said, the same general system is applied to all the other pieces manufactured in the room—of course, with such differences as the shape and nature of the piece may call for. I might, of course, have made the description of the machinery in the train department very much fuller, and, indeed, I might have filled all the lecture with the details of the work done here. I have, however, I hope, indicated enough to interest without wearying, and will leave the room after introducing one more automatic machine, viz., that in which the key, ratchet, and hand squares are cut. Here there are two dead spindles, to one of which is attached an index plate, divided at the quarters and held by a pawl. To this index the barrel arbor is attached by a dog, when it is inserted between the dead spindles. A milling head, carrying two revolving cutters at proper relative positions, passes in a horizontal direction over the barrel arbor, being driven forward by means of suitably arranged cams. The first cut being made and the cutters drawn back to their dormant position, the pawl is raised by means of a stop piece, and the index moved round one-fourth of the circle, bringing the next part into position for the second cut. This is repeated until the four sides are roughed, when the operation is repeated, so as to bring the cutters across the flat surfaces, in order to smoothe them, when, by a star stop-work arrangement, the whole machine is brought to rest. Thus, simply but effectually, is attained a very desirable end, viz., that of making a perfect square of any size, taper, and length, and of duplicating the first arrangement through any given series. We have now our plates and train, and we still lack 'scapements, screws, and balances. The same principles are applied to the machinery in the 'scapement department as in the train manufacture. The escape wheels are sent from the press-room crossed punchings. The teeth are cut on a machine similar in principle to the tooth cutter in the train department, only being more delicate and more intricate in shape, the operation cannot be done with one cutter, but involves the use of eight different cutter spindles. In the machine there are seven spindles, or we may say eight, each provided with a special fly cutter. The wheels are stacked on a quill similar to the one we found in the train department. The first four cutters are steel, and they are used respectively to remove the surplus stock between the teeth, to form the front undercut of the teeth, the back undercut, and the face angle. The last four cutters are of sapphire, and are used to finish the second, third, and fourth cuts, and to finish the heel of the tooth. One factory, that of Springfield, Mass., has an automatic attachment to this machine. But the disadvantage of its complexity, necessitating a machinist to run it, deducts materially from its advantages as an automaton. After cutting, the wheels are crossed by hand, drilled, hubbed, gilt, and fitted to the pinion which has been sent from the train room. The pallets and levers are rough punching, something the size and shape of the pieces they are to be made into, and are finished by simple drilling, milling, and slotting machines adapted to each requirement. After hardening, they are ground and polished, the flat surfaces and edges by abrasion on tin, or box-wood blocks with hand rubbers, the shaped surfaces by special rocking polishers. The stones come to the room in the usual state of rough nodules. These are cut into slabs by the skives and the slabs cemented on to blocks, ground to a proper thickness, again sawed into strips by the skives, removed from the

block, the angles ground and polished, and we are provided with pallet jewels. The ruby pins are turned and polished, from strips prepared as above, the machine used being a simple parallel grinder. The rollers being plain discs call for only simple drilling and turning machines. There are three varieties of lever escapement used, adapted to the straight line and right angle calipers. The last named, only, however we will mention particularly. The blank for the lever and pallets is sent up in one piece, the shape of the lever, but the thickness of it and the pallet combined; by three turnings, the pallet size is turned away, and by two cuts with a circular saw, the recesses for the stones are formed. The fork is then formed, and the guard pin hole drilled, and after hardening, cleaning, and polishing, a lever and pallets is obtained which with its attendant staff and jewels is ready for the movement at a cost of less than one shilling. The different parts

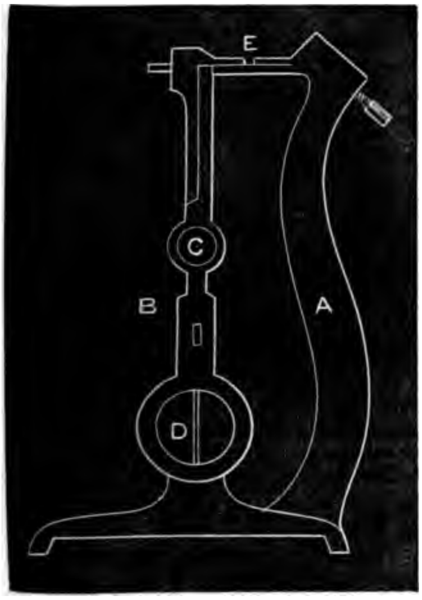
(Fig. 6.)



are now collected and sent to the matcher, who screws in the pallet staff; puts in the guard pin, matches each pair of pallets to a wheel, and sets right the let off or drop, his depthing tool being set to the plate depthing. The escapement matched, he places it in one recess in a box prepared for 100 sets, and it is ready for the movement. The screws and flat steel work are made in one department. In the flat steel work is included the ratchet and cap, star and finger piece, and the click and spring. Most of the pieces named are made from shaped or circular punchings, and are formed on machines similar to the leaf makers, by means of shaped cutters and saws. After hardening, the flat surfaces are ground and polished, mostly by lime, oilstone, and oil, or alcohol, and the shaped surfaces and edges by revolving and rocking polishers. The screws are made in spring chuck lathes, and are cut down to size by an ordinary cutter in a Swiss slide rest. The thread is made by means of a die spindle on line with the lathe spindle. The screw being tapped, is run into a cylinder of steel which is prepared to receive some hundreds in rows, either longitudinally or circumferentially. When the cylinder is full of screws, it is placed in a milling machine, and a small circular saw is made, by suitable means, to cut a slot along the centre of each row. The screws are then removed by the ingenious application of two roughed spring tight cylinders, which clip the screws just hard enough to draw without marring them. They are then hardened and polished with boxwood polishers, and Vienna lime and oil. After they are cleaned, blued, and inspected, they are ready for the watch. But one department remains for us to visit, wherein material is manufactured, viz., the balance department. The manufacture of the balance (compensation) is perhaps the one in which least of advancement has been made. In England the steel blanks are dipped, here the brass is soldered to the steel, and the remaining routine is but an adaptation of the old system, with the introduction of machinery where possible. The best application in all probability is on the machine for drilling the holes in the edge of the balance for the adjustment screws. This has a shifting head, so arranged as to bring round each one of the twenty two holes in regular succession, and with such rapidity can the operation be performed that a boy can drill and thread the holes in 100 balances in ten hours. The greying and polishing are effected in very much the same manner as in other jobs in the departments before visited. We now have our material, and we must proceed to get it into going order. We premise, however, that three articles used in the movement are manufactured outside the factory, viz., hands, mainsprings, and rough jewels. Arrived in the jewelling and motion department (the two are run in one room on account of the interchange of work which may often be made advantageously). The plates which we recollect to have seen fitted and numbered in the plate department, are put together, and the other requisite parts are selected, and each set is placed in a neatly-arranged sectional box fitted to take ten movements. This box is first sent to the jewellers, and the routine of the room is somewhat in this wise: The plates are screwed together and the depthings are uprighted. While this is being done others are setting the jewels, backing them, opening, washing, and gauging them. The girls who gauge the jewels also gauge the pivots and select jewels for them, allowing one twenty-five hundredth of an inch for side shake. The jewels being selected, if they are to be set solid, the brass settings are turned away and the top plate jewels are then set. The pillar plate jewels are next cut in, and shaken and burnished in. The balance jewels

are set in a similar manner to the plate jewels, and the holes are stripped after the plates are gilded. I have preferred to give this routine consecutively, as we could make it more understandable. I will now endeavour to give some idea of the manner in which the different operations are effected. The manufacture of the jewels themselves is carried on in much the same manner as in England, excepting perhaps the use of steam power, the gang skive, and an improved shellac chuck lathe. The gang skive consists of a set of circular saws or discs which are charged with diamond powder. The rough stone is cemented to a holder which brings it with great pressure into direct contact with the saws, and the result is that the material is divided into slabs just the required thickness for the jewels, whether holes, pins, or pallet stones. The jewels are next set. This is performed in the following manner:—A piece of drilled brass a little larger than the setting will be is held in a spring chuck lathe, and with a proper shaped cutter a bevelled recess is formed the exact size of the jewel, which is then turned off. This operation used to be performed by a hand tool, but it is performed now by a novel contrivance, which is adaptable to a great variety of uses. We refer to what is generally known as the siving rest, of which a diagram is given in

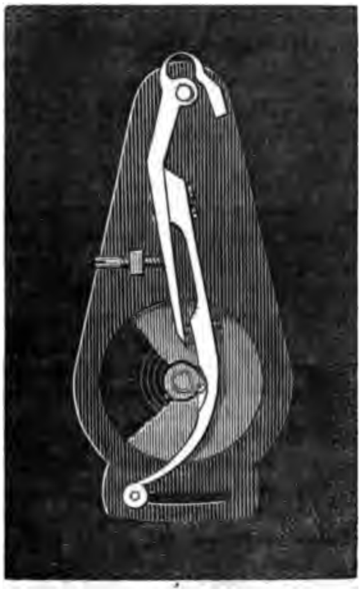
(Fig. 7.)



A is a fixed arm attached to the lathe stock. B is a cutter rest with a hole to carry the cutter spindle at C and swinging on a centre at D. The rest is carried as far above the spindle as the centre is below it, and at its head is a nose E sliding over a bed attached horizontally to the top of the fixed arm A, on which is rested the article to be measured. The action of course depends upon the well-known law of the proportional relations of circumference and diameter. Were we to take the measurement of the jewel and throw our cutter just its diameter from the centre of revolution, it is evident we must cut a hole just double the size required. But applying the law of radii, we double the radius; take the same jewel to make the angular distance and we find that our cutter at C will make the hole just the size of our model on the measuring bed. This tool is of almost endless application, and is sometimes constructed with an index bed arranged to allow of subtending the cutter spindle at any desired angle from the central line, so as to cut a taper hole. After the jewel is set it is backed off and then is sent to be opened. This operation is performed differently in different factories. Some adopt the old plan and hold the opener in the fingers as do the English. In most shops, however, the jewel is held in a rapidly revolving spring chuck, and a properly tapered opener is brought up to it and inserted, the latter being set a little off a right line, and the spindle in which it is set is made to revolve very rapidly but in the opposite direction to the jewel. The opener being charged with diamond powder soon produces a perfectly smooth round hole, a result never certainly attained under the old method. The holes opened are next washed and then gauged by a simple taper sticking against an index plate divided to correspond to the degrees on the fine jaw gauge. After the jewels are gauged the trains are taken, the pivots measured, and the jewels are selected for them, side shake to the amount of ·0004 of an inch being given. The pivots and other small diameters are measured by a simple yet effective spring jaw gauge, a drawing of which is given in Fig. 8. Next the top jewels are set in the plate, and here again the swing rest comes into play, enabling, as it does, the workman to cut his hole to size and depth at once. The top jewel set, the lower jewel must be fixed in its proper position. The top plate jewels are set flush with the lower surface of the plate. The next step is to get the correct distances between the jewel faces. How to make the pinions self-measuring was the problem to be solved. Its solution cost much trouble and thought, and to describe the method adopted is a difficult task, without rather more complicated diagrams than I can give this evening. The end to be accomplished was to cut the shoulder of the jewel setting just such a height as when set in the

plate, and the plates are screwed in their ultimate positions, the distance between the jewel faces shall be the height of the pinion and an end shake of ·0006 of an inch. If the settings are to be screwed in, the depth of the hole for the screw head is measured by a bit in the swing rest. If the settings are not screwed they are burnished in the usual manner. The balance holes, cock, and foot are operated in the same manner. After the watch is gilt, the holes are stripped, that is, a hollow is cut with a very fine surface from the top of the hole to the edge of the plate at an angle of 30. This is done by hand with a very finely tempered and polished graver, and requires a great deal of skill and nicety.

(Fig. 8.)



We now have our watch jewelled, and we must go with the movement to the motion department. Here we have to fit up the barrel, all of which is done with cutter and slide rest, the end shake being obtained by a self-measuring attachment and a shaped inside cutter. The pivot holes which are not jewelled are drilled through, opened, and uprighted in the quill chuck. The motion wheels, cannon-pinions, and hands are selected and fitted. The roller is fitted to the balance-staff, and the ruby pin is set, the bankings are screwed in, and the watch is set up and sent to the finishing room, where it is sprung and timed in the gray. It is then taken to pieces, and sent to the gilding room where it is stoned and gilt by the electro process. Thence it is returned to the finishing department where it is finally put together and set going. This labour is divided—one set of men and girls setting the train in position, another set springing and finishing the movement, a third set timing, and a fourth examining and correcting the faults of all the rest. And so at last we have the perfect movement with its glittering balance, counting the moments as they fly, and measuring the time with a regularity never surpassed in a similar grade of hand-made watches. Of course I have not been able to enter into details so far as I could have desired; but I think I have sufficiently indicated the manner in which the watch is built up. It would have been impossible for me to give you a detailed account of the machinery employed. Such a work would call for volumes. There are of course very many curiosities which I have been unable to notice in my rapid *resumé* of the departments. Among these I may mention particularly the parallel and cone grinders in the machine shop. These tools render it possible to grind to a perfect finish and exact truth and fit the spindles, conical and crescent bearings, &c. of hardened steel which are used in the machinery. This tool too is used in a modified form in the train department, where with diamond laps the staffs of scape pinions, pallet and balance staffs are ground to exact truth. Another tool in the machine shop is the compound chuck. This is a very ingenious tool, and is such that even if every watch of Elgin make were destroyed, and every chuck in the factory lost, the movement would be restored and every position in the original calibre regained by its aid, and the size and fit for manufacturing chucks at once identified as correct. It is, of course, very complicated, and demands a very great amount of skill in its manufacture. I have not spoken at all of the system of gilding, simply because the electro process is used, and it is so thoroughly used and followed by the trade throughout this country. Great facilities are, of course provided—the scratch brushes are driven by steam power, and the stoners are well provided for; but the arrangements are only such as would suggest themselves to any firm gilding on an average 200 movements per day. Nor have I mentioned particularly the manufacture of dials, which is carried on in much the same manner as in this country, the only difference being in the preparation of the coppers in order to make them interchangeable. There are three feet, and, of course, each must preserve a certain relative distance from the fourth hole. To accomplish this the coppers are cut out, and the centre and seconds' holes made by a punch of the requisite size. Then another punch comes down and makes three curious little recesses in the copper to receive the dial

These feet are turned to size and height iitable lathe, and are provided with a t the bottom. In setting up the feet as to soldering, the nicked end is in- in the recess spoken of just now, and ring of solder being dropped over the is all secured by a tap from a rivetting , and then is provided with flux and is to run the solder. As a consequence, ain two ends. We get our dials abso- interchangeable, and the feet are upright ve not to be bent about to make them he routine of the remaining operations it the same as in other places. And may be asked, what are the advantages machine system? In the first place, roduction of a mechanically perfect Be sure only that your model is right, u may be sure that your duplications e correct also. There is no fitting and , but the pieces brought from different of the factory will go together right. estion of perfection of finish is only a little more or less of cost, for no finish t been attained by hand which is not ible by machinery. In the second there is a vast saving in labour. In ctory from which I come there are red 600 hands, who produce 5,000 s per month; that is to say, they pro- me watch for every thirty hours of . I am informed, on good authority, medium class English lever costs seventy of labour. So that if the machine were in use in England the workmen kenwell could more than double their tion. And what a waste of the wealth country is this needless waste of labour. it England owns to-day has been earned , toil, toil. And surely an increase of duction, with a lessening of the toil, mean an increase also of wealth and By the adoption of the machine system id has the ability to manufacture for the Were she to adopt it in its entirety, y defy the Swiss with their cheapest ents, she may still lead the world with t class movements, and she may absorb e watch trade thousands of that hungry which now barely exist or else are to seek on some foreign shore that their own country denies them. The trade now is in a peculiarly prosperous ut if two or three years since, when re depressed, you had only taken hold machine system, you may have done by e what it will take years to do now, ay by this time have been sending s to the Yankees made with their own nd after their own style. I am not -night to ask Clerkenwell to adopt the system. I have reason for believing that the next few months will see the problem worked out. But I can say one thing, that, whether it come soon or late, the American system of multiplying machinery will be adopted in England, and when it is I expect to see first class English lever watches turned out from the factories at prices which I dare not hint at.

The CHAIRMAN said he was requested by the lecturer to invite questions or remarks bearing on the subject.

Mr. HARRISON understood that all the parts of the watches were not interchangeable.

Mr. SCHOOF supposed the Americans had not attempted to make fusee watches by machinery.

Mr. BICKLEY said the lecturer had not stated if the balance springs or cases were made in the factory.

Mr. PERKINS, in reply, said the parts were interchangeable with the single exception of the escapements. It had been found advisable to match the escapements. With regard to the fusee, it was simply a question of supply and demand; although the Americans had not made fusee watches there was nothing in the fusee to prevent its being made by machinery. Referring to Mr. Bickley's question, the balance-springs were turned up in the usual way in the factory by girls; the watch cases were made in Philadelphia and New York.

The CHAIRMAN said he had listened with much pleasure to Mr. Perkins's lucid description of the factory system of manufacturing watches. Whatever difference of opinion there might be as to the relative merits of the American and English systems, he was sure they would all agree that they were much indebted to Mr. Perkins for coming to lecture before them that evening, to whom he begged to propose a vote of thanks.

Mr. BICKLEY in seconding, remarked that judging from the specimens, the machine work would not be suited for the finest grades of watches.

The vote of thanks having been carried unanimously, was acknowledged by Mr. Perkins, who said that all the specimens shewn by him that evening were purposely selected from the lowest grades of work.

THE public clocks of Belgium strike the hour half-an-hour beforehand; thus at half-past eleven they strike twelve.

ERRATA.—In the report of the Exhibition in the December number of the Journal at page 50 second column line 19 for "roundness" read "soundness;" and at page 52 second column line 8 for "shot" read "slot."

Abstract of the Principal Changes of Rates of Chrono

NAME OF MAKER.	No.	ADDRESS OF MAKER.	CONSTRUCTION OF BAL
Weichert	2300	112, Rothsay Ter., Bute Docks, Cardiff.	Flat rim balance, without au
Usher & Cole	[illegible]	46, St. John's Sq., Clerkenwell, Lond.	Auxiliary to balance.
Kullberg........	2177	105, Liverpool Road, London.	Kullberg's flat rim balance, without au
Weichert	2339	112, Rothsay Ter., Bute Docks, Cardiff.	Auxiliary compensation.
Davison	4884	6, Side, Newcastle-upon-Tyne.	Auxiliary compensation.
Kullberg........	1885	105, Liverpool Road, London.	Improved ordinary balance.
Muirhead & Sons	2854	90, Buchanan Street, Glasgow.	Kullberg's flat rim balance, without au
Sewill..........	3070	30, Cornhill, London.	Auxiliary compensation.
Shepherd & Sons	1787	53, Leadenhall Street, London.	Auxiliary to balance.
Glover	357	8, Wrotham Rd., Camden N. T., Lond.	Auxiliary acting at all temperatures.
Parkinson & Bouts	1165	59, Gracechurch Street, London.	Auxiliary acting in extremes of tempe
Keys	260	15, Craven Street, Strand, London.	Ordinary construction with slight alter
Chittenden......	793	10, Wilton Road, Hackney, London.	Auxiliary as in former yea
J. B. Fletcher ..	3369	148, Leadenhall Street, London.	Auxiliary compensation.
Gowland........	2293	178, High Street West, Sunderland.	Auxiliary compensation.
Parkinson & Bouts	1128	59, Gracechurch Street, London.	Auxiliary acting in extremes of temper
J. Fletcher......	2679	148, Leadenhall Street, London.	Auxiliary compensation.
Lowry	776	66, High Street, Belfast.	Auxiliary compensation.
Quilliam........	17917	32, Elizabeth Street, Liverpool.	Ordinary balance with continuous auxil
Isaac	1129	147, Liverpool Road, London.	Balance as in former years ; no auxilia
Whiffin	361	10, Cloudesley Sq., Islington, London.	Auxiliary compensation.
Sewill	3064	30, Cornhill, London.	Auxiliary compensation.
J. B. Fletcher ..	2969	148, Leadenhall Street, London.	Auxiliary compensation.
Keys	261	15, Craven Street, Strand, London.	Ordinary construction with slight alter
Isaac	1125	147, Liverpool Road, London.	Remodelled Hartnup balan
Hennessy	4869	5, Wind Street, Swansea.	Auxiliary compensation.
Williams	123	2, Bute Docks, Cardiff.	Auxiliary compensation.
Whiffin	352	10, Cloudesley Square, Islington, Lond.	Auxiliary compensation.
Highley	5435	45, High Street, Sheerness	Auxiliary acting in cold.
Brotherton	5417	11, Spencer Street, Goswell Rd., Lond.	Construction as in former y
Lowry	778	66, High Street, Belfast.	Auxiliary compensation.
J. Fletcher......	2921	148, Leadenhall Street, London.	Auxiliary compensation.
Sewill..........	3267	61, South Castle Street, Liverpool.	Auxiliary compensation.
Gowland	1285	178, High Street West, Sunderland.	Ordinary construction with slight alter
Shepherd & Son..	1789	53, Leadenhall Street, London.	Auxiliary to balance.
Davison	4793	6, Side, Newcastle-upon-Tyne.	Auxiliary compensation.
Webb	5608	4, Pullen's Row, Upper St., Isling., Lon.	Auxiliary as in former yea
Muirhead & Sons	4447	90, Buchanan Street, Glasgow.	Poole's auxiliary.
Sewill..........	3252	61, South Castle Street, Liverpool.	Auxiliary compensation.
McGregor & Co ..	4580	Clyde Place, Glasgow.	Auxiliary to balance acting at low tem
Russell & Son ..	2089	30 & 32, Slater Street, Liverpool.	Auxiliary acting in cold.

The sign + indicates that the rate is gaining.
During four weeks from the 3rd of March, and during four weeks from the 24th of May, the Chronomet placed in the chamber of a stove heated by jets of gas. The gas flames are exterior to the chamber, into whi of the injurious products of combustion can enter.
The ratings commenced January 11th, and ended August 9th, so that the duration of the trials wa weeks.

ial at the Royal Observatory, Greenwich, 1873.

t ly	In what Temperature (degrees Fahrenheit.)	Greatest Weekly Sum.	In what Temperature (degrees Fahrenheit.)	Difference between the Greatest and Least.	Greatest Difference between one Week and the next.	In what Temperature (degrees Fahrenheit.)
		s		s	s	
·5	38 to 45	— 4·4	65 to 79	5·1	3·0	41 to 51
·6	64 to 72	+ 3·1	52 to 61	5·7	3·5	52 to 61
·6	38 to 45	— 7·7	52 to 56	6·9	3·6	38 to 45
·4	do.	+ 4·5	65 to 79	9·9	4·3	48 to 56
·6	do.	+ 17·1	52 to 56	12·5	4·6	41 to 51
·8	48 to 54	+ 5·0	63 to 69	11·8	5·2	41 to 51
·8	38 to 45	+ 12·4	67 to 74	15·2	4·2	52 to 61
·1	65 to 79	+ 2·5	48 to 56	9·6	7·5	48 to 56
·4	35 to 41	+ 12·6	65 to 79	13·0	6·7	41 to 51
·8	76 to 89	+ 3·0	35 to 41	16·8	6·2	38 to 43
1·6	48 to 56	+ 4·9	63 to 69	16·5	7·0	41 to 51
2·8	48 to 54	+ 15·0	67 to 74	17·8	6·6	43 to 52
3·9	do.	+ 9·7	63 to 69	13·6	8·8	52 to 61
0·5	do.	— 2·4	48 to 56	18·1	6·8	52 to 61
3·5	65 to 79	+ 11·4	52 to 61	14·9	9·5	41 to 51
7·4	38 to 45	+ 6·3	65 to 79	13·7	10·1	41 to 51
13·4	do.	0·0	81 to 96	13·4	10·8	41 to 51
1·0	48 to 54	+ 19·4	48 to 56	20·4	7·3	43 to 52
4·1	48 to 56	+ 14·3	67 to 74	18·4	8·5	48 to 56
11·0	66 to 85	+ 29·9	64 to 72	18·9	8·4	48 to 56
22·3	54 to 62	— 5·4	35 to 41	16·9	10·0	41 to 51
6·6	76 to 89	+ 7·8	39 to 46	14·4	12·0	41 to 51
6·2	35 to 41	+ 17·9	52 to 61	24·1	7·4	63 to 69
2·1	48 to 54	+ 20·1	67 to 74	22·2	8·5	41 to 51
1·9	do.	+ 23·1	85 to 95	21·2	9·4	52 to 61
5·1	58 to 79	+ 12·3	{48 to 56, 82 to 90}	17·4	12·3	41 to 51
19·2	35 to 41	+ 3·3	{52 to 58, 67 to 74}	22·5	10·0	41 to 51
5·9	48 to 54	+ 28·2	48 to 56	22·3	11·9	48 to 56
18·6	38 to 45	— 0·1	52 to 61	18·5	15·2	38 to 45
14·6	do.	+ 3·9	67 to 74	18·5	16·3	41 to 51
12·0	48 to 54	+ 49·7	63 to 69	37·7	9·0	48 to 56
16·7	65 to 70	+ 15·2	52 to 61	31·9	12·1	63 to 69
8·5	48 to 54	+ 24·3	67 to 73	32·8	12·3	43 to 52
18·9	do.	+ 12·4	do.	31·3	13·7	41 to 51
24·2	38 to 45	— 1·0	65 to 79	23·2	18·5	41 to 51
17·6	35 to 41	+ 16·7	82 to 90	34·3	14·9	41 to 51
1·7	58 to 79	+ 32·7	85 to 95	34·4	17·9	64 to 72
28·1	85 to 95	+ 2·4	48 to 56	30·5	20·9	63 to 69
3·7	66 to 85	+ 42·5	63 to 69	38·8	16·8	64 to 72
18·4	38 to 45	+ 13·4	81 to 96	31·8	23·2	41 to 51
6·3	41 to 51	+ 10·4	67 to 73	26·7	9·3	63 to 69

Chronometers are placed in order of merit, their respective positions being determined by considera- the irregularities of rate exhibited in the Table above.
Chronometer Russell and Son 2089 was found stopped on August 7. On examination by the maker it ed that the main-spring had broken. On account of the shorter duration of trial the rates of this meter are placed in a separate division at the foot of the general list.
he Chronometers were two days. The lowest temperature in which they were tried was 35° Fahrenheit, hest 96° Fahrenheit.

Letters to the Editor.

All letters to be addressed to the Editor, at the Institute, 35, Northampton Square, E.C.

SIR,—My observations in the November number of your journal upon measuring tools for the lever escapement having been honoured by a reply on the part of Mr. Grossmann, in which he points out, an error in my explanation about finding the length of lever, and refers to an error in his essay, permit me to state that I did not for one moment suppose the error of his to which I referred would remain long undiscovered by Mr. Grossmann himself, therefore my reference to it was not with a view so much to its correction as to assist me in the explanation of my gauge for measuring the lifting angles of pallets and the reason of my deducting 2° from the angle registered upon the plate.

Mr. Grossmann states that the allowance of 2° in all cases would not be correct, (although I did not intend my remarks to bear that inference,) and instances the circular pallets, in which the error is so small as to render it too unimportant to notice; but as regards pallets with equi-distance lockings the case is very different, and it was with reference to these pallets that my observations were made. I must confess to not having sufficiently carefully measured the discharging pallet to discover at the time that the error was nearer 1° than 2°.

As regards the error in my explanations about finding the length of lever, and which Mr. Grossmann illustrates by an excellent diagram, in reference to which he says "If the sum of a b + b c were equal to a c, (as I represent,) there would be only a moment of action at the line of centres, and all action would cease at ever so little distance from this line." I beg to say that this is assuming the ruby pin to be of no size whatever, for if it be of any size half its diameter would be within the notch of the lever, it therefore follows that all action would not cease at ever so little distance from the line of centres.

I may also state that the lengths of levers given in my examples are from the pallet staff hole to that part of the notch which is in contact with half the diameter of the ruby pin when in line of centres, and I did not intend it to be inferred that the notch was to be no longer, as it necessarily must to ensure a sound depth, and I further selected this system of measurement as one by means of which a close approximation to the balance impulse is most easily calculated and understood, and as the error from it is so small I did not think it worth mentioning in my article, which I intended only to have reference to the means I adopt for measuring the impulse at the balance.

In conclusion, I thank Mr. Grossmann for pointing out the error and thus affording me an opportunity for this explanation. I should feel obliged to Mr. Grossmann if he would kindly state if he has a better means of measuring an escapement than my gauges afford.

R. B.

SIR,—Permit me to correct an error that appeared in the *Journal* for November in the answer to Junior, in which the writer asserts the amount of locking to be dependent on the shape of the pallets alone, and that the only result of a ruby pin having too much shake in the notch, would be loss of impulse to the balance. In the first place, the shape of the pallet has nothing whatever to do with the amount of locking, for whether a pallet is 8, 10, or 12 degrees of angle, the same amount of locking is essential to each, viz., about two degrees of the presumed angle, and that amount is entirely dependent on the planting, and more or less than two degrees would constitute a deep or shallow depth. But to Junior's question. If a wheel and pallet depth be a shade shallow, although perfectly safe, and the notch in the lever is too wide for the roller pin, the pallet depth to such an escapement would mislock when tried by itself, although it is doubtful whether it would do so when going with the spring on, for as Junior expresses it, both parts are moving together in which case the wide notch is simply loss of impulse, whereas, tn trying an escapement, the balance is held in resistance to the pressure applied to the wheel while traversing the plane of the pallet, which keeps the lever pressed against the roller pin until the tooth escapes, when the lever and pallet becomes a free agent, and rebounds from the point of pressure to the extent of the wide notch, consequently mislocks, while increasing the size of the pin to fit the notch, the rebound is prevented and the depth made safe, but if a wheel and pallet depth be really shallow, no increase of pin would make it safe. To verify the correctness of the above, remove the ruby pin to a perfect escapement, and replacing it by one much to small, the depth will at once appear shallow.

Yours, &c.,

J. L. TILLING.

Sir,—It is with regret I see Mr. C. Lange's vident irritation about my criticism on his pinions in the October number of the *Journal*. t is the more to be regretted, as a great misake was inadvertently made in putting it hat Mr. C. Lange had said that the fusee vas advocated to deceive the ignorant amongst vatchmakers. This evidently could not be o. Mr. C. Lange said, "Unless it is done to nake the great mass of people, who are enirely ignorant of watches and watchmaking, elieve that it is better to have a fusee and hain in a watch than not, I cannot see any eason why watches should be made with usee. Everything that reasonably can be xpected from a watch can be made without he fusee," &c., &c. Now, I considered such pinions, in order to be of any use in a watchnaker's trade journal, required a full and atisfactory confirmation. Mr. Lange, if I nderstand him rightly, admits in his Decemer letter that a watch with fusee will vibrate nore regularly than a going barrel; but, to my surprise, he says that has nothing to do with the question. I should like to know what has, unless some new method has been discovered that will make watches go well, without attending to niceties in construction, &c. Mr. Lange further says that if the original suitable spring breaks and an ordinary spring is put instead, it will spoil the adjustment. Admitting this, but even under such circumstances we know that the fusee will make a far better adjustment than the unaided barrel. Old-fashioned verges will prove that. Mr. Lange therefore seems to come to the conclusion that, because watches are ruined by bad jobbers, it is useless to strive at perfection at the outset. I still adhere to my opinions in the November letter—that going barrels are quite good enough for cheaper kinds of watches, but when it comes to the question of great nicety, and of making the finest timekeepers for the pocket, every means in our power must be used to arrive at perfection, not so much from choice as from necessity, and every chronometer maker of eminence in any country will bear me out on this point; the very fact that watches are placed in all positions, and, therefore, require the isochronism to be much wider than stationary timekeepers, and, further, not being so regularly wound as could be desired, makes the fusee more needed for a high-class watch than any other timekeeper. I mentioned in my letter that the going barrel falls off a quarter of a turn from full wound to nearly down. Mr. Lange does not find it so, and he goes so far out of his way as to say that not "even" a common horizontal will do so, when we all know that frictional escapements, such as the horizontal and duplex, are much more suited for the going barrel than comparatively free escapements, such as the lever or chronometer; the word "even" is therefore, in this case, decidedly misplaced. I am surprised Mr. Lange does not deem it necessary to send his watch to Greenwich; it would, besides being a means of settling a disputed question, add immensely to the maker's reputation, and unquestionably do Mr. Lange, as "agent," a great deal of good. Mr. Lange's advice to sign names to articles is very good, but that does not add to the soundness of the argument, and since it is quite a common practice not to do so, I sign myself as before,

A MEMBER OF THE BRITISH HOROLOGICAL INSTITUTE.

Sir,—I am sad—melancholy in the extreme! Not that my personal suffering can be of any consequence to your general readers; but when they learn that it arises from the doomed fate of our chronometer trade, I am sure their sympathies will be with mine.

Hitherto English marine chronometers have borne a world-wide reputation for their excellent performance, but, alas! all this must disappear before the results obtained from Swiss watches. In the Horological Journal of December, 1873, there is mention of one of ordinary size which made a variation of only $\frac{6}{10}$ths of a second during a period of two months, either in the hanging or lying position—less than a single beat of a clock. This has scarcely been accomplished with marine chronometers, even with perfect balances. I would suggest that this watch made no appreciable error at all, and that $\frac{6}{10}$ is merely set down to appease our conviction of the principle we are taught, that nothing which is made by human hands is perfect. Why, Sir, what will be the consequence of this? Captains of ships will henceforth buy Swiss watches, and hang them up in their cabins, and after being on the broad sea for two months, will be able to calculate the longitude almost to exactness. What a pity it is that such watches are not placed in the Royal Observatory at Greenwich, where of course they would head the competitive trials with marine chronometers, so that the shame of defeat might stimulate our chronometer makers to renewed exertion, and at least make them endeavour to produce instruments equal to ordinary-sized going barrel Swiss watches.

Believe me, &c.

A. P. WALSH.

To Correspondents.

AN AMERICAN CORRESPONDENT *writes "I have been shewn a silver-cased watch, No.* 511 *Engraved on the back, "B. Franklin,* 1776." *The maker's name " Wm. Tomlinson, London." The present owner is Levi W. Groff, a farmer of Lancaster, County Pa. He wishes to know whether anything is known of this Wm. Tomlinson, or whether he has any successors in the watch trade."*

[*We trust that some reader can give the required information. That Benjamin Franklin had an English watch is interesting, in presence of his alliance with France to drive us from his country.*]

G. V. S.—*Many thanks for pointing out the omission. Mr. Grossmann's rejoinder shall appear next month.*

M. B.—*A work giving the information for which you ask is published by J. Davy & Sons, Long Acre. Ask for Chronometer size at any of the tool shops.*

British Horological Institute.

DIARY OF MEETINGS FOR JAN., 1874.

DAY.	DATE	TIME.	BUSINESS.
Friday	2	8.30	Finance Committee.
Monday	5	8.0	Technical Class.
Tuesday	6	8.30	Council.
Thursday	8	8.0	Technical Class.
Monday	12	8.0	Ditto.
Tuesday	13	8.30	Half-Yearly Gen. Meet.
Thursday	15	8.0	Technical Class.
Saturday	17	8.0	Presentation of Prizes.
Monday	19	8 0	Technical Class.
Thursday	22	8.0	Ditto.
Monday	26	8.0	Ditto.
Thursday	29	8.0	Ditto.
Friday	30	8.30	Finance Committee.

[**Members are particularly requested to attend the half-yearly meeting.**]

MESSRS. E. DENT and Co., have recently cleaned the going train of the Westminster clock, which has we believe, been stopped but three or four times, during the fourteen years it has been the regulation of the metropolis. On the last occasion, some three years ago, the going and striking trains were cleaned, after a fire which had occurred in the tower; but previously to this, the clock had been going continually, excepting in two or three winters when an accumulation of snow upon an ornamental moulding round the dials, obstructed the passing of the hands. It now scarcely shows signs of wear; and during the month previous to cleaning, its accumulated error upon no occasion exceeded one second.

LIST OF NEW MEMBERS.

ALEXANDER, WM., Jeweller, Gordon and Buchanan-street, Glasgow.
BELL & ATKINSON, Lancaster.
BLACKHURST, JOHN, Watch and Clock Maker, Market-street, Crewe.
BRIDGMAN, R., Examiner, Prebend-street, N.
COHEN, JAMES, Clock Maker, 2, Bruges-terrace, Stepney.
DYER, GEORGE, Watch Maker, 90, Regent-street, W.
GREENHALGH, J. J., Watch and Clock Maker, 3, Lord Duncan-street, Salford.
GREYGOOSE, A., Weybridge, Surrey.
HANCOCK, C., Jun., Bond-street, W.
HAWKINS, E., 13, Warren-street, Tottenham Court-road.
HORSTMANN, HENRY, Watch Maker, Weston-super-Mare.
JOHNSON, E. SUTTON, Watch Maker, Charnwood House, Derby.
MACKINTOSH, —, 31, Hanover-street, N.
MARTIN, J., Case Maker, 47, Gerrard-street, N.
MORTON, G., Watch Maker, 31, Hanover-street, N.
MOUNTAIN, CHARLES GEORGE, Engineer and Millwright, Suffolk Works, Birmingham.
NELSON, J., 50, Walton-road, Liverpool.
PERKINS, THOS., Inspector, National Watch Company, Elgin, Ill., U.S.A.
PIDDUCK & SONS, Goldsmiths and Jewellers, 24, St. Ann's-square, Manchester.
PRICE, JAMES, Watch and Clock Maker, 101, High-street, Ashford, Kent.
POWNALL, H. W., Bank Manager, St. Margaret's, Twickenham.
RAINFORTH, J. T., Watch Maker. Bridgwater, Somerset.
SALSBURY, R., 56, High-street, Guildford.
SCHWERT, CHAS., Watch Maker, 39, Edmund-street, Birmingham.
SEALY, —, Tunbridge Wells.
SUTTON, G. F., Watch Maker, 10, John-street, Pentonville.
TROTTER, JOHN T., 131, Westgate-road, Newcastle-on-Tyne.
WEBBER, HENRY, Springer and Timer, 13, Lucas Terrace, Leytonstone, E.
WEICHERT, W., Chronometer Maker, 119, Bute Docks, Cardiff.
WEIGHTMAN, EDWIN, Watch Manufacturer, 11, St. John's-street-road, E.C.
WHEELER, F., Narracoote, South Australia.
WHITEHORN, THOS., Watch and Clock Maker, 18, Heath-street, Hampstead, N.W.
WILSON, GEO., Watch Maker, Penrith.
WOOD, C., Bredhurst, Chatham.
WULFF, HENRY, Watch Maker, 188, Broad-street, Birmingham.

British Horological Institute.

HE distribution of prizes, which took place at the Mansion House, on Saturday, January 17, forms the last step in the proceedings connected with the Exhibition. results of the experiment have been satisfactory and successful beyond expectation. trade where ordinarily so much isolation exists, to find numbers ready to contribute r specimens of work, and those men of the first rank in their respective departments an encouraging omen; the quality of the work exhibited sustained the reputation of, the character for precision to which Clerkenwell lays claim, pre-eminently above all es in the world. The favourable notice of the Exhibition which appeared in the *Times* other papers gave a sudden celebrity to the house of the Institute, in Northampton- ire, the crowds of visitors being out of all proportion beyond the convenience of the ding or the expectations of the Council. The large attendance of the outside public evinced ong desire on their part to make themselves better acquainted with the actual merits English watchwork, which have been so often unfavourably compared with the produc- s of foreign countries, and the favourable opinions expressed by many of the visitors no doubt in some measure account for the many applications for space after the open- which, unfortunately, could not be complied with. To a success so unexpectedly t the conclusion at the Mansion House was most appropriate. The central area of the ling (the reception-room on all State occasions), in which the Lord Mayor arranged for prizes to be given, was thronged, more than 1,000 members of the trade, with their ids, being present. The glitter of the chandeliers, and the gilding of the cornices and columns, with the Lord Mayor in his official robes, surrounded by his suite, as dis- tor of the prizes, made the evening memorable.

ie President was warmly received, and listened to with attention till he reached his ents on the merits of the Exhibition and of exhibitions in general, when symptoms ssent pervaded the assembly. The opportunity of addressing the trade does not often to the President, though the columns of the *Journal* are at all times open to his com- cations. We were therefore surprised at his strangely severe remarks, depreciatory of xhibition, in a meeting where all were prepared for congratulation. His strictures hat he terms mere finger-work, and his complaint that prizes were given for polishing s, &c., evidently proceed from a misconception, as a reference to the scheme put for- by the Council, the Judges' report, and also to our report of the Exhibition in the nber number of the *Journal*, will show. In our report we alluded to these minor s as proof of the extreme attention to detail shown by the workmen, but certainly put them forward as excellencies deserving the award of a prize. As regards finger- it is unnecessary to point out to the readers of this *Journal* that when brainwork, or, her words, science, has done all it can, finger-work, or, as watchmakers term it, ing, will ever remain an important element in the production of good watches. Our lent himself admits that "good execution must be cultivated in watches, in order to ce good work." The praises bestowed by the President on the American system of ig watches by machinery in factories, afforded an opportunity to Sir J. Bennett for ring one of his characteristic speeches, eulogistic of Swiss watches, and depreciatory glish watches and watch making. He enlarged on the need of education, especially ical education, and of his own great efforts in that direction. This is indeed bitter coming from a man who has never subscribed to any technical education for watch s, and who is not even a Member of our Institute.

ting these drawbacks on which we have commented, we may congratulate the trade of nwell on having given an example to the Trades and Guilds of the City which they o well to follow.

HALF-YEARLY MEETING OF MEMBERS.

The half-yearly meeting of the members, for receiving the report of the Council and the transaction of ordinary business, was held at the Institute on Tuesday, January 13th; Mr. John Jones, F.R.G.S. (vice-president), presiding.

After reading the minutes of the previous general meeting, the secretary read the following

Report for the Half-Year ended the 31*st of December*, 1873.

"The Council have much pleasure in presenting for the half-year a Report shewing that the Institute is making satisfactory progress. Every important source of revenue appears to be steadily increasing. With a larger income, the Council have been enabled to considerably enlarge the size of the *Journal*, and to accomplish many objects, long in view, but compelled to remain in abeyance for want of funds.

"The distinctive feature of the half-year is the Exhibition of Work referred to in the last report, which has been not without considerable labour, brought to a successful issue; all that remains to be done being the distribution of the prizes, which has been undertaken by the Lord Mayor. Necessarily, in an experiment of this kind, many incidents have occurred, suggesting improvements possible in arranging a future exhibition, but, taking the number and quality of the exhibits, and the amount of interest awakened in the trade generally, the Institute may be congratulated upon the result.

"The Council received with gratification from the gentlemen deputed to examine the Students their report, recently published in the *Journal*, expressing satisfaction with the progress made by the class generally, and awarding two silver medals and other prizes to the pupils most proficient. These prizes will be presented by the Lord Mayor, at the Mansion House, concurrently with the distribution of the Exhibition awards. The educational department of the Institute is evidently of paramount importance, and the Members will no doubt feel with the Council that no effort should be spared to maintain its efficiency. With the assistance afforded by the Worshipful Goldsmiths' Company, facilities are offered to young members of the trade for obtaining technical instruction, such as are possessed by no other craft in London.

"By the resignation of Mr. Mayer, who was unable to continue the great sacrifice of time demanded by the honorary office, the *Journal* has lost an able Editor. Members are earnestly invited to assist the Council by sending for publication in the *Journal* any matter likely to be of interest to the trade generally.

"By the kindness of the Astronomer Royal, Members have been enabled to inspect the instruments at Greenwich Observatory. The pleasure of the visit was enhanced by the particular courtesy and attention of W. H. M. Christie, Esq. and other assistants of the Astronomer Royal, who undertook explanations of the various objects of interest. For a second view of the Westminster Great Clock, the Members are indebted to the First Commissioner of Works. The thanks of the Council are due to Mr. Perkins for his Lecture descriptive of the machinery used in the United States for the manufacture of watches, a subject which cannot fail to be of interest to all watchmakers.

"The Council, with pleasure, acknowledge the following gifts:—

"Six copies of a pamphlet, 'On the Construction and Theory of the Dead Escapement for Clocks,' by the late B. L. Vulliamy. Presented by his son, George Vulliamy, Esq.

"One copy of 'A Description of the Timekeeper invented by Mr. Thomas Mudge,' from Mrs. McDowall.

"Twenty-four numbers contained in Vols. 1 and 4 of the *American Horological Journal*, from the proprietor, Mr. Miller.

"A Blue-book on 'Hall-marking,' from Professor Tennant.

"A Skeleton Horory Sphere, from Mr. E. D. Johnson.

"'Greenwich Observations' for 1868-69-70, and 1871' (4 vols.,) presented by the Astronomer Royal.

"Patent Office Reports for 1869-70, and 1871,' (7 vols.) from the United States Government.

"Thirty-five new Members have been elected during the half-year.

By Order of the Council,

(Signed) F. F. Britten, Secretary.

"*Balance Sheet for the Half-Year ended* 31*st of December*, 1873.

Dr. Income.	£	s.	d.
To Balance in Treasurer's hands, last audit	19	18	10
,, Building Fund	50	0	0
,, Donation from Goldsmiths' Company, applicable to the half-year	25	0	0
,, Subscriptions	88	13	0
,, Sales of Journals	46	0	3
,, Advertisements	59	15	1
,, Drawing Class Fees	1	5	0
,, Sundries	0	6	4
,, Contributions to Exhibition Fund	11	9	0
,, Six Months' Interest of Building Fund	1	5	0
	£303	12	6

Cr. Expenditure.	£	s.	d.
By Rent and Taxes	31	18	4
,, Salaries, Wages, and Commissions	53	17	11
,, Journal Expenses	99	9	10
,, Stationery, Stamps, &c.	6	9	3
,, House Expenses	4	2	2
,, Printing and Advertising	7	9	6
,, Sundries	5	4	7
,, Exhibition Expenses	24	4	10
Balance	232	16	5
By Cash in Treasurer's hands	19	11	1
,, ,, Building Fund	51	5	0
	£303	12	6

"We have examined the above statement, together with the books and vouchers, and certify the same to be correct, this 13th day of January, 1874.

(Signed) C. H. Hawkins, James Pyott, } *Auditors.*"

The Chairman, in moving the adoption of the report and balance-sheet, said that, owing to ill-health, he had been absent from many of the Council meetings during the half-year, and in consequence was not so conversant as he should be with the subject-matter of the report. At present the trade of Clerkenwell was in a very prosperous condition, but the advancement of the Institute was not coincident with the prosperity of the watch and clock making, but was due, in a great measure, to the energy and ability displayed by their secretary. The item, "building fund," in the balance-sheet brought to his mind the encouragement they had received from the Marquis of Northampton. Nothing was said in the report indicative of any further steps having been taken to secure enlarged premises for the Institute. Perhaps the secretary could give them some information upon the point. He considered that the fact of the Lord Mayor giving his countenance by distributing their prizes was singularly appropriate, seeing that the Lord Mayor, being elected by the different guilds, was really the only representative of the London trades. Their exhibition was altogether a pleasing matter, and for real usefulness would bear favourable comparison with the more pretentious exhibitions annually held at South Kensington, which, so far from being an unmixed benefit, were viewed with alarm by many leading members of the trading community, as subjecting tradesman to an unfair competition, by providing a house free of taxes for foreigners to sell their goods. Mr. Mayer was unable to devote the time necessary for editing the *Journal* for a further period; the members, he was sure, fully appreciated the labour Mr. Mayer had already given them. The burden of editing the *Journal*, which he had resigned, and which was ably sustained for many years by Mr. Strachan, now devolved upon their Secretary. The Secretary reminded him that the task of finding original matter rested, to a great extent, with members of the Council. He (the chairman) could not help thinking that the members generally could assist with contributions more freely. There were a few members who frequently favoured them with articles. Mr. Dennison, of Bradford, had recently opened an important and interesting subject, but there was room for many fresh contributors. By their combination as a society they had been enabled to obtain the interesting visit to the Greenwich Observatory mentioned in the report, to inspect the antiquities and the splendid instruments now in use for observing the motion of the heavenly bodies. They could not boast of many lectures during the year; the time had been when those who induced lecturers to come there, bringing, perhaps, apparatus costing much time and labour, were dismayed and confused into shame by finding only three or four people present. However, brighter times had dawned upon them, and he trusted that their progress would be continuous.

Mr. Jackson (treasurer) had much pleasure in seconding the adoption of the report and balance-sheet. The financial portion was more particularly his department, and the improvement shown in their balance-sheet was particularly gratifying to him, inasmuch as he had a vivid recollection of the many occasions when they were compelled to submit a discouraging financial statement. No one was better aware than he of the efforts their Chairman had made in bringing gentlemen of ability and distinction to lecture at the Institute, and he could assure him that in future the Council would consider it a point of honour to secure an audience. Having presided at the last lecture, he could say that the lecturer had no cause of complaint in the number or intelligence of his audience.

Mr. Prosser said a proof of the advancement of the Institute was to be found in the interest taken in their proceedings by the general public. He held in his hand a Birmingham daily paper, which had been sent to him that morning, containing a long report of their recent transactions.

Mr. Bickley thought the report very gratifying. He confessed he should have preferred more specimens of work at the Exhibition than were shown. It was a matter of surprise to him that Lancashire should have been wholly unrepresented there. He agreed with Mr. Jones that exhibitions such as theirs were productive of good; they afforded an opportunity for study and pleasure to an intelligent

man, who could not fail to get some hint or new idea for examining the work in the various branches. He thought they had reason to be proud of the distinction shown them by the Astronomer Royal in opening his gates to their members. Mr. Ellis said during their recent visit that so large a party had never visited the Observatory before. The great increase in the income from sales of journals and advertisements was especially gratifying, and would have resulted in a larger balance, but that the amount paid on behalf of the Exhibition expenses to the 31st December exceeded by £13 the contributions to the Exhibition fund received by that date.

The report and balance-sheet having been adopted unanimously,

The CHAIRMAN rose to propose the motion of which he had given notice—"That the Baroness Burdett-Coutts be elected an honorary member of the Institute"—and remarked that no apology was necessary for his proposition to accord to the Baroness Burdett-Coutts the highest honour it was in their power to bestow. When the Exhibition of work was mooted by Mr. Bohme, he (the Chairman) waited upon her ladyship, who entered into the details of the scheme, and satisfied herself of the good likely to result, before giving the project her countenance. The offer of the prize of £50 for the best essay on "Compensation" came spontaneously from her ladyship. He was sure the members present would agree with him that they were fortunate to secure the co-operation of so distinguished a lady.

Mr. JACKSON was thankful for the privilege of seconding the nomination of Lady Burdett-Coutts, whose beneficent acts always bore evidence of that rare quality of judgment. Having accompanied Mr. Jones on the occasion referred to, he could bear testimony to the interest her ladyship took in such work as the Institute was endeavouring to accomplish.

The resolution having been enthusiastically carried,

Mr. BICKLEY, in accordance with notice standing in his name, moved that Sir Charles Wheatstone, D.C.L., LL.D., F.R.S., be elected an honorary member of the Institute. He reminded the members that honorary membership had been devised as a means of associating with themselves eminent men of science, of whom there could be no more brilliant example than Sir Charles Wheatstone, who had never scrupled to give them his assistance, even though it involved arduous labour. He (Mr. Bickley), as a member of the Exhibition Committee, had an opportunity of observing the painstaking manner in which Sir Charles Wheatstone acquitted himself of the office of juror. The acquisition of Sir Charles Wheatstone would shed honour and lustre upon the Institute.

Mr. BACON seconded the nomination, which was carried unanimously.

Mr. JACKSON, on rising to propose, in accordance with previous notice, that Mr. George Mayer be elected an honorary member, said they could not better show their appreciation of the services rendered by Mr. Mayer, a gentleman of undoubted literary ability, who, when they were left without an editor, stepped in and conducted their *Journal*. He did not say there was no point in his management to which exception could be taken, for "to err is human," but he thought twelve months devoted labour was worthy of the highest honour they could confer.

Mr. EVANS seconded the motion.

Mr. BICKLEY wished, at the outset of the few remarks he felt compelled to make, in opposition to the proposition of Mr. Jackson, to disclaim any personal feeling towards Mr. Mayer other than respect. It was a well understood and intelligible rule that honorary membership, the highest honour the Institute could bestow, should be reserved as a recognition for exceptional services rendered by distinguished persons, and he feared if Mr. Jackson's motion was agreed to it would form a dangerous precedent. If the principle were admitted, he could point to the great and constant services of their Chairman (Mr. Jones), to the arduous work of Mr. Jackson and others, as deserving this exceptional honour. He would even speak of his own services; without egotism, he could say he had worked hard and constantly for years, often when the affairs of the Institute were in a discouraging state. Let him not be misunderstood, he did not crave honorary membership; he would not accept it if offered; all round they were bound to work hard and make sacrifices, and the only logical deduction from Mr. Jackson's proposal was that they should elect each other honorary members all round. It was far from his wish to detract from Mr. Mayer's services; he would join cordially in a vote of thanks, or subscribe to a testimonial, but it would be his painful duty to vote against the present motion.

Mr. GANNEY, in supporting the resolution, adverted to the services which, he said, himself, had rendered to the watch trade, more particularly in spending four years in the United States investigating the manufacture of watches by machinery, and thought the translation of the works of the elder Jürgensen which had been undertaken by Mr. Mayer, well worthy of the proposed recognition.

Mr. SCHOOF thought it only right they

should make some recognition of the labour involved in the translation of Jürgensen's work, commenced by Mr. Mayer with singular ability, as he could testify from having read the original work. He had often wondered how Mr. Mayer could find the necessary time, and when they lost his services as editor he (Mr. Schoof) feared the translation would lapse. Mr. Mayer, however, promised to complete it, and would, no doubt, have continued it regularly but that he had been busily engaged lately. Probably the case would be met by electing Mr. Mayer a life member, which would remove the objection to Mr. Jackson's proposition, and, he thought, be equally acceptable to Mr. Mayer. He would move an amendment to that effect.

Mr. JACKSON said that as the value of any decision would depend upon its unanimity he would, with the chairman's permission, withdraw his motion and second the proposition of Mr. Schoof, suggesting, however, as an addition, that a set of volumes of the *Journal* should also be presented to Mr. Mayer; to which Mr. Schoof consented.

Mr. BICKLEY had much pleasure in supporting the proposition. He thought Mr. Ganney misunderstood the nature of honorary membership, which was really the Victoria Cross of the Institute.

The motion that Mr. Mayer be elected a life member, and that a set of volumes of the *Journal* be presented to him, was put and carried *nem. con.*

Mr. G. Barter, of Wilmington-square, and Mr. G. Morton, of Hanover-street, were elected to fill vacancies on the Council.

A vote of thanks was accorded to the President of the Institute (Mr. Denison,) on the motion of the CHAIRMAN.

Mr. JACKSON proposed a vote of thanks to the Vice Presidents, and regretted that so much of the Vice Presidents' work devolved upon their Chairman, Mr. Jones; at the same time they must not forget the past services of Mr. Johnson, to whom he might say was due the inception of the Institute, or the arduous work given by Mr. Klaftenberger in their earlier days.

Mr. POOLE, in seconding, took occasion to challenge the statement so often made that we were losing our foreign market for watches, instancing a case of his own experience where our watches were supplanting high-priced French work.

Mr. JONES, in acknowledging the vote of thanks to the Vice-Presidents, bore testimony to the indebtedness of the Institute to Vice-President Johnson, to whom no honour could be rendered in excess of his deserts.

The services rendered by the Auditors, the Secretary, and the Press were acknowledged, and the proceedings brought to a close by a vote of thanks to the Chairman for presiding.

DISTRIBUTION OF PRIZES BY THE LORD MAYOR.

THE prizes awarded in connection with the Exhibition of Work, and to the students in the Technical Classes were distributed by the Lord Mayor, Mr. Aldermen Lusk, M.P., at the Mansion House, on Saturday, January, 17th., in the presence of a large audience including the President, (E. B. Denison, Esq., LL.D., Q.C.,) and many members of the Council.

The Lord Mayor, in opening the proceedings, said he was pleased at having an opportunity of helping to forward the ends of technical education. It was difficult to find time for one thing and another, and he regretted that his time was so taken up by other matters as to be unable to assist oftener at such meetings. Their time on earth was limited, and unless they could live as long as Methuselah they would never be able to bring about a satisfactory settlement of matters connected with the technical education of the people. The object of the British Horological Institute was a most laudable one, as it tended towards the perfection of watch and clock making. He hoped none of them would think they had yet arrived at perfection, as nothing should be considered as being perfect. The longer they lived the more they learned, and this as well as similar institutes, contributed greatly to the improvement of education and learning. He remined them that although England had long the pre-eminence in their valuable art, she was now closely pressed by foreign competition. They could see ornamental French clocks in the windows, and in drawing rooms, and a large number of persons carried Swiss watches. He thought they ought to produce those articles in this country as ornamental and as cheaply, and any system of competition which could be introduced would be good. There was great competion everywhere nowadays, and Englishmen, who had the best heads and the best brains, should cultivate them so as to keep ahead of all other nations. It was true the climate of this country was not so favourable to workmen as that of France or Switzerland, as Englishmen required stimulating food, and that made living more expensive. He believed, however, that Englishmen possesed the best developed intellects in the world, and they must exercise them in order to remedy any climatic defects there were in this country, and acquire a good technical education, which was as important to them as general education was to be the whole people. Not only as Lord Mayor, but as member for Finsbury, he had always sought to promote education, both general and technical, and it was in furtherance of this object he presided there that evening,

He felt sure they would all try to succeed, and if they did not obtain success, then they would do their best to deserve it.

Mr. Denison, Q.C., President, said he did not know until a few minutes ago what would be the course of proceeding this evening, nor what kind of address would be expected from him. He had then been asked to take advantage of the large meeting, which he was glad to see, to give a short account of the progress of the Horological Institute and its present work. It was started in 1858, before he was connected with it, and it was pleasant to remember that that connection arose from a lecture which he had been invited by the Council to give to the members, in the large room of the Society of Arts, in 1866, on the subject of "Large Clocks," to which they probably knew that he had devoted special attention for many years—he might say, from when he was a boy. He was afraid he had been rather a bad member of their Council, though he had done all he promised when he accepted the office of President, having always attended meetings to which he had been invited for any special reason, provided they were not in his own professional working time. He had also faithfully kept his promise never to attend any public dinners, as he never did so for any institution, or on any occasion whatever, though it sounded like heresy to say that in the Mansion House. The Institute had for some time to struggle with difficulties, and especially in what was perhaps its most important work, carrying on the *Horological Journal*, which he was glad to hear had now reached a sale of 1200, including a continually increasing demand in America. That *Journal* afforded the means of publishing every novelty of horological interest. It is recognised by the Astronomer Royal, who sends the reports of the Greenwich trials of chronometers, as does Mr. Hartnup those of the Liverpool Observatory. He had been told that evening that the Astronomer Royal had lately invited the members of the Institute to a visit of the Royal Observatory, a privilege granted very sparingly; for such visits cannot take place without to some extent interfering with the work of the Observatory, and the stars wait for no man. Moreover, the Council of the Royal Astronomical Society, of which he was for the present a member, had lately agreed to send their *Monthly Notices* to the Institute, a publication which (as has been said by one not particularly friendly to that Society) "contains the materials from which the history of Astronomy is written." Indeed, the connection between Horology and Astronomy is too obvious to need enlarging on. Time is an element of every astronomical observation relating to the motions of the heavenly bodies, including those used for finding unknown longitudes. And the very reason why chronometers are tried continually at Greenwich and Liverpool, and the best selected for purchase by the Admiralty, and the rates of them all published, is to encourage the continual improvement of that important instrument, testing it (he wished particularly to observe, with reference to the coming business of the evening,) by the only test of any value—its actual performance. The Institute has also a library, to which the members can resort, of whom there are about 400, and they receive the *Journal* gratis, and can attend all lectures at the Institute. Speaking of them, he would specially mention a recent one of great importance, on the American system of watchmaking by machinery, which is carried on there far beyond anything that is attempted here, and that is the reason why the Americans can beat us in the markets, even our own, where cheap and yet reasonably good watches are required. He was glad to see from that lecture, and from what he had heard otherwise, that there is at last a real prospect of a complete watch machinery establishment in England. If the Americans, with the enormously high nominal wages that prevail there (for it does not appear that workmen can get more with them) can undersell us, it is evident that we ought to beat them with the same system properly worked here. He had been told since he came here, that the English watch trade never was more flourishing. But what had they to say to the Lord Mayor's very true remark, that you see French clocks in every drawing-room, and he might have added American ones in every kitchen, and Austrian ones in many halls, and Swiss watches in every lady's hand, and in many gentlemen's; and also to the fact noticed in the *Times* the other day, that the import of foreign watches and clocks increases vastly every year? Returning to the subject of lectures at the Institute, he said that every person of experience knows that it is impossible to keep up any regular system of really useful lectures on any art or science: the materials and the men do not exist for it. They must be content with such occasions as present themselves, and perhaps the lectures excite more interest from not being regular, and being only given when there is something to be said of special importance to their trade. As he had been speaking of the gradual advance of the Institute in public recognition, he ought not to omit the permission of the Board of Works to the members to visit the Westminster clock on two occasions, and the liberal donations of Lady Burdett-Coutts, for prizes

which he should have to speak more parnlarly,) and of £50 from the owner of the ritory on which the Institute has its habitan, Lord Northampton, who, he understood, l also promised to assist them further in aining premises better adapted for the work the Institute. One important part of it had not yet touched. The Lord Mayor had ken of the value of what is called "technieducation;" and he had heard with some prise, since he came into this room, that the rological Institute was the first, and until te lately, the only public body in this City ich offered technical education to its own mbers, and he believed to other stuts. As somebody seemed to demur to this, would repeat more specifically that he lerstood that it was owing to the represenons of one of the most active members of ir Council, Mr. Jones, that the Goldsmiths' npany had lately established some technical ures of their own. There is among the City Companies one called the Clockkers' Company, and they once came forward heir corporate capacity to make a represenion against the proposed construction of the stminster clock. He did not know whether y had yet in any way taken up the Instie, but one would think there ought to be ie connexion between them, which might beneficial to both, or, at any rate, to the one ich has been and is doing whatever has n done to advance the knowledge of Horoical science. Some of the rewards which Lord Mayor was going to administer, were drawing from Horological models in the sses of the Institute. The prize offered by dy Burdett-Coutts, for an essay on the mpensation Balance, is not yet adjudicated; t there was a similar one last year on the chronism of the balance. And now he apached a ground on which he felt obliged to press opinions which would probably not be reeable to a good many of the audience, but vertheless he believed it would be for their erest to hear them, and to reflect on them. m of them had heard him express similar inions at a meeting of the Institute a few ars ago. But a man who thinks he will, ate an impression by expressing an opinion an argument once or twice must have very tle knowledge of his fellow creatures. He ust repeat it very often, and especially enever circumstances turn up which enable n to enforce it. Now, passing on to the prizes actual work done in the educational classes, inst which he had nothing to say, here are o sets of prizes given, one for literary comition of an essay on some horological subt, and the others for exhibited work. He l read a good deal of the prize essay of last year, and it entirely confirmed the opinion he had formed long ago of the value of prize essays; in fact, among persons of any literary experience, "a prize essay" is almost synonymous with an attempt at finer writing than the author is master of, containing nothing of the smallest value to mankind. When you want to test young men's literary acquirements, it is quite right to set them to show those acquirements by writing essays, or other kinds of composition. But what earthly use to anybody can there be in encouraging young watchmakers to waste hours in painfully writing, in many pages, what may be found almost in as many lines, and infinitely better done, in various elementary books of science or mathematics? I see, (he proceeded) that the editor of the *Journal* was so stunned at some of the author's views, on what may be called the mathematical elements of his subject, that he put in a note to remind the readers that he was not responsible for them. Perhaps I ought not to say more of the defects, for I have no wish to blame the author for not doing what he ought never to have been encouraged to do. And I dare say the judges, (though I hear they were not unanimous,) really chose the best of the essays sent in. But I do say that such a result ought to be a warning against encouraging any more such waste of time. These young men have to make their living, and perhaps advance to the highest position in their calling, like those dead and living horologists whose names are familiar to most of us, not by writing essays on the elements of the art, but by acquiring practical skill in it, and discovering improvements if they can. I have yet to remark on the remaining subject of this evening's prizes, for work in the late Horological Exhibition. There again I have not the least doubt that the judges have selected the best work of its kind. But I am far from satisfied that that is the kind of work which it is profitable or desirable to reward. The Lord Mayor naturally spoke of "inventions," believing he was going to give prizes for them; and if I had been in his place, and had not read these awards of prizes —I mean especially the medal and money prizes—I should have expected as he did, that we were going to reward inventions by which horology has lately been advanced, or is likely to be. But what are we really going to give these prizes for? Why, for polishing screw heads, and the flat sides of wheels, and things of that kind. Some of you may remember my laughing at a meeting of the Institute at the importance attached to "facing pinions," and I asked, and ask again, how many people in England have the most remote idea whether the pinions of their

watches are faced or not, or even what it means; and what is more important, will any man in this room venture to say that a watch will go the smallest degree better or worse, whether its pinions are faced or not, or whether the wheel faces are polished, or the screw-heads left "grey"? Old Earnshaw, the real father of the chronometer as it is now made, began fighting that battle nearly a century ago, and though, being an independent and original man, great people tried all they could to keep him down, he made them admit that his unpolished and even his unselected chronometers beat the highly finished and selected ones of Arnold, who was patronised by the grandees of that time, and has been generally since talked and written of as if he invented the chronometer and Earnshaw had been nobody. I had for some years to fight the same battle with respect to large clocks. When I began what I may call the reform of them at Dent's factory about twenty-four years ago the settled price of large church clocks was from £400 to £500. A large proportion of this went for labour which was utterly useless for any practical purpose—as useless as facing pinions and polishing screws of watches now. By simplifying the work, introducing the gravity escapement, which requires no delicacy of execution or finish, prescribing cast iron for all the larger wheels, and prohibiting all unnecessary polishing, by the provision in specifications that all non-acting iron surfaces are to be painted, the price of turret clocks has been reduced considerably more than half, in fact, to about forty per cent. of what it used to be for clocks of the same size, while their accuracy of performance has been so much improved that whereas the old-fashioned makers, if they would give any guarantee for rate at all, guaranteed one to within five minutes a week, I now always insert in specifications five *seconds;* and other people tell me that they have reduced the errors of their own clocks in just that proportion. I willingly accept what somebody said in derision of the Westminster clock, that "it looks like a patent mangle;" but still you know it goes better than any astronomical clock with the finest dead escapement that was ever made. That is just the difference between science and art in these matters. The art of clock-making had been carried to the highest possible pitch, *i.e.*, the work that was designed could not possibly be executed better than it was and is in the best regulators. They had reached their limit, and yet that limit was a long way from perfection. I have seen rates of the very best regulators, which show clearly that the rate is capricious and can never be depended on with certainty, even to keep in one direction for any considerable time. That is in a great measure removed, and, though I am far from thinking even clocks perfect, there are now clocks of several constructions, with gravity escapements and those of the chronometer class, which appear from Greenwich information to have rates rather measurable by tenths of seconds a week than by seconds. It is true that clocks are not watches, and that watches depend far more upon accuracy of execution of very minute and delicate work than clocks. And it is also true that no invention of any particular value has been made for watches since Earnshaw brought the chronometer into its present form, except in the secondary compensation of the balance. Therefore I admit that good execution must be cultivated in watches, in order to produce good results in a much higher degree than in clocks. Some of the prizes are unobjectionable (subject to a question affecting all such rewards), but I cannot help saying, however disappointing it may be to some of you, that polishing of screws and facing of wheels, which are specially noticed in the report on the late Exhibition in the *Journal* of last December, and all work of that kind, does not really deserve a prize of twopence. Encouraging that kind of mere finger-work has a tendency to discourage that brainwork, on which the Lord Mayor truly said that our advance as a nation must depend. I must say further, that I am not certain that it is not altogether a false principle to encourage people to do the regular work of their calling by special prizes. The proper reward to a man for doing his work better than other people is that he can command the market of employers and get higher wages and reputation, of far more value to him permanently than any such prizes as we can give. It is true that there are men and combinations of men now striving to suppress all individual merit, and therefore all improvement, by demanding that bad and good workmen shall be paid alike, and preaching the insane doctrine that the country or their own class will be richer the less work each man does; as if the wealth of the country dropped down from the sky, instead of every bit having to be raised out of the earth and made valuable one way or another by labour; so that the less each man does, below the proper measure of his strength (which of course ought not to be exceeded), the less is done upon the whole, and the less wealth there is to spend again. Take a very simple illustration of this. Suppose you were told that, from some disease, advancing with sure steps, and certain to affect everybody, every man's strength would be

permanently reduced one half. You would regard it as a frightful calamity, and nobody would be so stupid as not to see that the nation would be so much poorer for it. Yet that is what those fanatics are driving at who fancy there will be more money to be spent among them the less work they do. I know that such people are past argument, and I am not expecting to convert them, but only to warn you against them. While the Lord Mayor was speaking I wrote down these three words as a memorandum, "Do your best." That is the way that all men have got on who have got on and reached eminence. As he said, if other people are getting up at seven you must get up at half-past six, if you want to beat them; and the only proper limit that I know of for a man's work, whether it is of head or fingers or both, is that he should not do more than he can with advantage to himself. Overwork is as bad as underwork. For some months in every year I have to bear that in mind myself, and to do as much as I can during the day and no more, taking proper rest every day and every week. Acting on that plan, of doing everything you have to do as well as you can, you will get on 100 times better than by all the prizes that could be given if we had twenty times the money to distribute. It does not seem to me that those on whom the work of the country depends, *i.e.*, the much-flattered "working men," to whom politicians who want their votes profess to attribute all wisdom, have the least idea how much the prosperity of the country, and therefore of themselves, depends on these simple truths. I think I should be doing much less good by flattering this assembly of horologists and their friends with assurances that there is nothing in the world so good as the highly-finished work for which the prizes will be given presently, than I may do by asking you to reflect whether there are not more important objects than these prizes to work for, and whether English horology does not require scientific more than merely manual cultivation.

The LORD MAYOR then distributed the following Exhibition prizes, of which full particulars were given in the *Journal* for December, 1873:—Silver medal of the Institute and £5 to G. Abbott; £5 to J. L. Tilling; £5 to R. Gore; £5 to G. Morton; £5 to - - Andrews; £5 to W. Sills; £3 to R. Bridgman; £2 to J. Ody; £2 to Mrs. Mann; £1 to H. Lee; and £2 to W. C. Smith, an apprentice. Also framed certificates of honourable mention to T. Nelson, W. Smith (of Coventry), R. Foster, F. T. Lawrence, L. Finegan, C. V. Nyman, G. F. Sutton, Thos. Buck, H. Webber, J. Martin, R. Bridgman, T. B. Fraser (of Kenilworth). W. Twitchings, Reymond Bros., and T. Harris.

Mr. JONES rose to ask the Lord Mayor to allow Mr. Glasgow,—who had been one of the Council on whom the chief labour of the Exhibition had fallen,—to reply to the challenge which the President had given to the policy of the proceedings. For himself, he respectfully attributed those comments to a want of acquaintance with the mode and objects of the Council. The word finishing may probably have misled the President; it is not a word of general signification, but a technical term; it implies the preparing and planting the parts in due relation to each other so as best to transmit power, and if some superfluity of polish be thrown in it is but an insignificant addition to the labour. The prize was not for a complete watch, but for its parts, each part forming a separate trade. The parts of a watch were a series of mathematical ideas expressed in steel or brass, and the ability to produce such forms involved a life of cultivati n of the nerves and——

The LORD MAYOR interposed, and asked Mr. Jones to allow the presentation of the prizes to be proceeded with. He then distributed the following prizes to the students in the Technical Class, as enumerated in the Examiners' report published in the *Journal* for October, 1873:—The Institute's silver medal to D. Glasgow, jun., and T. Nelson, jun.; the author's edition of Grossmann's prize essay on "The Lever Escapement" to F. Mills; and a drawing-board and square to H. Hogan.

Mr. GLASGOW said he stood before that large meeting with feelings of mingled confusion and regret, confusion and surprise at the address they had just listened to from the president of the Institute, and regret that coming (as he did) to the meeting with other duties to perform, he was unprepared to reply in an efficient manner to the speech they had just heard. He also regretted much to have to differ from nearly every word the president had said, personally he had the utmost respect for him, and they were all proud to have a man so eminent and able to preside over their Institute. But unprepared as he felt and unwilling as he was to thrust himself forward on that occasion, he could not allow the slight cast upon the judges to pass without raising his voice in their defence, but when he mentioned the names of Sir Charles Wheatstone, Mr. V. Vulberg, and Mr. John McLennan, they (the meeting) would feel that defending these gentlemen would be superfluous, it would be sufficient to say that three men were more capable of forming an accurate judgment of what was or what was not

worthy of a prize in watch work could not be found in the whole trade. But was it right of the president of the Institute to come there, and not only throw cold water on their proceedings to-night, but actually to pooh pooh their exertions in connexion with the exhibition and indeed the exhibition altogether. He acknowledged the obligations of the trade to Mr. Denison who had himself made the best large clock in existence, and caused nothing less than a revolution in turret clock making; but he was not a watch maker and there was a great difference between making a clock that required eight hours to wind up and making watches; he had heard Mr. Denison say he felt rather flattered by some one comparing his great clock with a mangle; but watches could not be made like mangles or they would go like mangles, and he might remind him that the object of the Institute was to promote the making of good rather than cheap watches. A watch was a very small machine, too small to be made by any other machine, and quite impossible to make up reliable quality without a very high degree of finish. As to American machine made watches of which he had heard so much they had nothing to learn in watchmaking from the Americans, and as a proof that the American watch had not in any way supplanted us in our own markets—he could tell them from his own certain knowledge that the American made watches were not brought into competition with English or even Swiss watches in any of the central or South American Republics, and if it were not for the enormous import duty imposed we would still have a large trade in the United States. He had often said before that watchmaking was more an art than a science—the late Mr. Charles Frodsham said somewhere that there were men in our trade who could not do any thing badly, yet could not give a reason for doing it well. Yet, notwithstanding that drawback, we then made the best watches in the world. we did so still, and if the young men of our trade would avail themselves of the facilities offered by this Institute to acquire a knowledge of the scientific principles on which our art is based they would be able by combining this knowledge with the old manipulative pre-eminence to defy competition in good watches in the future as they had done in the past, and he begged his friends not to turn aside from that study of excellence in pursuit of which he and they had spent the best part of their lives, by anything they had heard that night.

Mr. Jones, on rising to thank the Lord Mayor, said that nothing had been wanting so far as the place or person were concerned to give lustre to the evening's doings. The Lord Mayor was a representative of Finsbury, and the only man in England the direct representative of the trades. He had instituted a new Order of Merit. The City often delighted in forming in the East a sort of counterpoise to the splendour of the West, and in the bestowal of these medals and honours the Lord Mayor had exercised somewhat of royal power. These marks of distinction would be worn with pride, nor did he think in the neighbourhood of Clerkenwell they would suffer in comparison with such honours as Sir J. Bennett enjoyed, for he (the speaker) judged that extra prefix to his name rather a troublesome addition. (Sir J. Bennett, speak for yourself.) In regard of an agricultural show, the landowner, the king, or queen might rightly enough give rewards; but the Lord Mayor was the fit person in matters of trade. Some of our predecessors had found a rest in Westminster Abbey; it would possibly agree with Sir J. Bennett's desires to wish him an early admission within those venerable walls.

Sir John Bennett, in seconding the motion, said that thirty years ago England was unrivalled in watchmaking, but now foreign nations were not only equalling them, but driving them out of the markets of the world. In clocks, not one of a thousand sold in England itself was of English make. The Swiss were their great and most dangerous rivals, and in order that they might be able to compete with them they should promote the employment of women in the trade, and technical education should be diffused more widely than was now the case.

The resolution was carried unanimously, and the Lord Mayor briefly acknowledged the compliment.

Mr. E. J. Thompson said he thought they should not separate without offering their thanks to the judges. He considered those gentlemen were entitled to approbation both for the principle they had acted on in the decisions arrived at and the particular rewards bestowed. It had been said that prizes should only be given for excellent performance. He begged respectfully to differ from that view. Just let them see what there was in the case. When Dr. Hook first applied the pendulum spring to watches it was expected they would go so well that the longitude might be ascertained from timekeepers, but it was not so; and Harrison long afterwards, in consequence of his inventing the chronometer escapement and the maintaining power to the fusce, received the prize of £20,000 offered for a timekeeper which would not vary more than two minutes—equal to half a degree of longitude

uring a voyage from England to the West ndies, then usually occupying a period of bout six weeks; but just notice the improveients since Harrison's time in the perforiance of chronometers. For many years overnment gave yearly prizes to the makers f the best chronometers after trial at Greenich Observatory, and during later years the onditions for their performance were not that ie variation might be minutes in a few weeks ut a few seconds only during many months, r instance, to obtain the first prize of £300, was required that the rate of variation eing taken for the first month of trial there iould not during the succeeding eleven ionths be a variation exceeding three seconds, ad the first prize was won over and over gain until Government declined to give urther prizes, believing the fact of excellent erformance was settled, and that the honourible competition of the makers of timekeepers vould ensure the production of first-rate hronometers for the use of mariners, and, herefore, he ventured to say that so far as erformance was concerned, their trade was early a perfect one, and thus it was necessary hat prizes should be offered for such excellent orkmanship of parts as had been given that 'ening. He therefore, with great pleasure, oved a vote of thanks to the judges.

Mr. Denison said he had great pleasure in conding the vote of thanks to the Judges. otwithstanding his previous remarks on the ture of the prizes, he had no doubt the dges had done the best within the lines laid wn for them. Probably no one in the room id such means of estimating the difficulty of ieir task as himself; for he had been one of ie judges who had to award the Horological rizes in the 1851 Exhibition. He was quite ware that they had not then satisfied the xhibitors, and he had certainly not satisfied imself, for the same reason which he had iven before, viz: that the only real test of good watch-making is trying how the watch will go. He was much struck with what Sir J. Bennett had told them of the effect produced on his mind by the Swiss watches in that Exhibition. He had himself no idea before then of the excellence of some of the foreign watches: he had been under the impression that its only quality was cheapness. Sir J. Bennett knew far more of their trade, of course, than he did, and his remarks upon its prospects were the most important they had heard this evening; and if they did not agree with what the President himself had said, they would probably think Sir J. Bennett's statements about the position of the English rade in relation to their foreign competitors worth very serious consideration. There was only one other point on which he must say one word, viz., Mr. Thompson's astounding statement that the chronometer was perfect. He could not understand an instrument being called perfect so long as the best that could be said for it is that it sometimes has very small errors. He never met with a horologist of any class who did not admit that the best chronometers cannot be made equal to the best clocks, though every now and then a single chronometer goes for a certain time with a wonderfully small error of rate. Had they not all been reading in the newspapers during the last year that one of the great difficulties in solving what had been truly called "the noblest problem of Astronomy," finding the distances and mass of the sun and all the planets by the transit of Venus next December, was the difficulty of being certain of the longitude and the local time at the places of observation? If the chronometer were perfect that difficulty would have vanished. At this hour however, he would say no more than warn them against living in the fool's paradise of believing that their work was perfect, or that the English clock and watch trade is in a safe state.

The resolution was also carried unanimously, and, having been acknowledged by Mr. V. Kullberg on behalf of the jurors, the proceedings terminated.

We learn with regret that the *American Horological Journal* has ceased to exist. Much valuable information is contained in the four volumes constituting its life, for which watchmakers on both sides of the Atlantic are indebted to the enterprise of Mr. Miller. Even were Horological literature more abundant, we could ill spare a magazine so useful as the *American Horological Journal*.

In 1605 a clock was put up in the cathedral at Frankfort. It consisted of three parts or divisions; in the lowest, which looked like a calendar, were several circles, the first of which showed the days and months; the second the golden number, with the age and change of the moon; and the third the dominical letter. The fourth and fifth circles represented the ancient Roman calendar. On the sixth were the names of the apostles and martyrs, the length of the days and nights, and the entrance of the sun into the twelve signs of the zodiac. The seventh and eighth circles exhibited the hours and minutes when the sun rose and set. In another circle the divisions of the twelve signs of the zodiac, the four seasons, and the twelve months were marked. A circle in the centre showed the moveable feasts.

A NEW IMPROVED MERCURIAL PENDULUM.

At p. 119, Vol. XIV we reproduced from the American *Horological Journal* a treatise upon a new improved Mercurial Pendulum, by Moritz Grossmann, and a criticism by 'Clyde' was inserted at p. 139 of the same volume. Our attention has been called to the fact that a full reply to "Clyde" followed at the time in the American *Journal* which in justice to Mr. Grossmann and to complete this interesting subject we subjoin :—

"You have been kind enough to mention to your readers the reasons that made me rather slow in my correspondence, and I am very much obliged to you for doing so, as my silence with respect to "Clyde's" remarks in No. 2, Vol. II., of the *Journal*, on my suggestions referring to improvements in the mercury pendulum, might have been interpreted as indifference to the subject spoken of, or to the public spoken to. I wish to uphold my opinion on the matter, as expressed in the June issue of your journal, and to give the reasons why I think it correct; but before entering into "Clyde's" remarks, allow me to refer to a previous correspondence of the same author, Vol. I., No. 10. For greater completeness, and in the interest of those readers who have not this number within their reach, I beg to repeat the article in question :

"For several years past I have been engaged in investigating all the questions that are involved in the pendulum as applied to the measurement of time, and all concerning the beautiful natural laws that govern the vibrations of the simple pendulum, and the more complex and incongruous questions involved in constructing the compound pendulum, and the numerous methods of compensating it.

The object of the present communication is to point out a fact, in connection with the mercurial pendulum, that appears to me to be a contradiction between the relative differences in the expansion of mercury and steel, as is accepted by the trade all over the world, and the amount of mercury used in the ordinary class of pendulums, whether the mercury be contained in one large jar or a number of smaller ones. All authorities agree that the linear expansion of mercury contained in a vessel about two inches in diameter is five and a large fraction times greater than steel. Reid, in his 'Treatise on Clockwork,' makes it not quite 5.75, while on the authority of Charles Frodsham its greatest expansion cury *one-half* of what it has been by altered under the same circumstances is 5.81 times greater than the *same length* of steel that usually composes the rod.

"Having cited these authorities, which are sufficient for the present purpose, let us suppose that forty-two inches of steel is the amount to be compensated (it is usually more), and, for simplicity, let us assume that mercury expands *six* times more than steel; in round numbers seven inches of mercury would compensate forty-two inches of steel. That is to say, by an excess of heat the rod has been lengthened, and the bottom of the jar let down, say one inch, while the same heat has caused the *top* of the mercury to rise one inch also, and the reverse action would be produced by cold. But it is plain that the centre of oscillation being at a point a little above the *centre* of the mercury, this point has only been altered by the action of the mer- the action of the steel; or, in other words, while the heat has lengthened the rod and let down the whole seven inches of mercury that constitute the bob, only one-half of it rises up to compensate for letting down the whole mass.

"In these approximations I take no account of the weight of steel or other material that constitute the jar, rod, etc., or the shape or expansion of the jar, nor the effect of heat or cold on the pendulum spring; all these combined have a tendency to considerably increase the seven inches of mercury that I have assumed; neither do I take into account the effect of the various escapements on the vibrations of the pendulum, but must be understood to be arguing about compensating a free pendulum, independent of the varying forces of any mechanism that impels it. And I would solicit the opinion of your readers in America or Europe on the subject."

When reading this I was rather surprised to see how a person, who had evidently been seriously reflecting on the subject, could have got into so strange an error; and I would have written immediately to explain the matter, had I not thought it very likely that one of your American readers might do the same thing, and it have been published before my letter could have reached you. This expectation, however, has not been fulfilled; and since I am obliged to speak of the mercury pendulum again in answer to "Clyde," I think it right to give him at once the explanation he has asked for.

I have Ried's Treatise at hand, and there are different statements in it relating to the expansive ratio of mercury as compared with that of steel. On page 350 he says: "The expansion of mercury is said to be fifteen times than of iron," On page 354 he gives Berthoud's Table, in which the expansion of soft steel is 69, and that of mercury 1235; or as 1 to 17.9. Page 355 states, according

to De Luc, the two expansive ratios to be 0112 and 1835; or as 1 to 16.56. On page 361 he says: "Philosophers seem not to be agreed respecting the expansion of mercury, in comparison with that of other metals, some making it 15, others 16 times greater than steel." Immediately afterwards Ried tries to draw a conclusion about the expansion of mercury from the ultimate effect of the mercury in Graham's pendulum; certainly an unfortunate idea, since he leaves out of his calculation that only the half of the mercury column can come into consideration for raising the centre of oscillation, to say nothing of the corrections for the gravity of the jar and rod, and for the expansion of the jar, all of which unite to diminish this ultimate effect. By these omissions he finds that it appears that the expansion of mercury is not quite 5.75 times that of steel. "Clyde's" remarks show sufficiently that he is quite aware of all the above-mentioned circumstances, and therefore it is strange to see him quote this erroneous* statement of Ried, without any consideration of the proceeding by which this latter came to that opinion.

Ried's excellent treatise was written at a period when natural science was not so much developed as now, and in all such matters it would be more advisable to quote authorities of more recent date. I do not know what Frodsham says, but if he makes the linear expansion of mercury 5.81 times that of steel, a man of his qualification can only have meant it under the afore-mentioned suppositions; but then, of course, he has used an incorrect expression. There are modern authorities enough who corroborate the figures first quoted by Ried, and *they all agree* more or less exactly with the tables of Lavoisier and Laplace, who give the expansion of soft steel as 0.001079, and that of mercury 0.018018; or nearly 1 to 16.7. These figures have to be corrected, when constructing a pendulum, according to the dilatation of the jar; and the expansive ratio of mercury in a glass jar will be 0.016348, and in an iron jar, 0.015598. In the first case, taking the expansion of steel as a unit, we obtain 15.15 to be that of mercury, while in the other case it is only 14.46.

These proportions found by Lavoisier and Laplace are generally accepted in the scientific world, and serve especially as a base for the correction of the barometer readings in different temperatures. If any scientific instrument can be considered as giving a correct idea of the expansive ratio of mercury, it is the thermometer, for its reading is a direct measuring of dilatation; but the steady rate of a mercury pendulum is of a vastly different nature, and hence the mistake of Ried, which "Clyde" has adopted. I come now to answer "Clyde's" criticism concerning the improvements in mercury pendulums proposed by me in No. 1, Vol. II., of the *Journal.*

In the first place, "Clyde" objects to the statement that in artificially heated rooms a difference of temperature like 3° R. could exist within the limits of a seconds pendulum's length. To support my statement, I refer to the universally acknowledged laws of nature; but "Clyde" does not deny them, he only thinks their influence of much less importance than what I quoted. I certainly do not wish "Clyde" or any of your readers to place my own experiences higher than what he sees with his own eyes, but the above statement has been made long before me, by several persons who are considered standard authorities in the scientific world. I have before me a memoir of Mr. Kessels, of Altona, published in an astronomical annual, the editor of which was the celebrated Schumacher, of Altona, one of the greatest astronomers of our century, stating, on the ground of repeated experiments, the difference spoken of to be 3° and even 4° R. This memoir is written in French, and is very interesting, and if you should think it useful, I would with pleasure translate it for the JOURNAL.

If the experiments made in the United States do not lead to the same observations, I think the mode of heating the rooms there may, to some extent, account for it. In Germany all rooms are heated with stoves, which is indeed very different from the open fire and the hot-air pipes in use in your country. Besides, so far as I know, the rooms in your country are on a general average higher than ours.

The length of my pendulum is no mistake, as "Clyde" supposes.

Further, my opponent admits that there is apparently something plausible in the theory of making the compensating parts of the same thickness; but, at the same time, he declares it a fallacy to do so in practice. He comes to the conclusion that the mercury of the Graham pendulum is acted upon even quicker than the thin steel rod, in consequence of the supposed greater susceptibility of the mercury; and he accounts, by this hypothesis, for the paradox mentioned by him in his article in No. 10, Vol. I.

Next to this, he finds I have forgotten the difference between the mercury pendulum and the gridiron one, arising from the circum-

* Ried's statement would be quite correct, indeed, if he had called it the ultimate effect of the mercury in a pendulum of the dimensions and materials as he describes it, instead of the expansive ratio of mercury as compared to that of steel.

stance that in the former the ball (mercury) increases and diminishes in length, while in the latter the entire ball is raised and lowered. According to my opinion, this difference is not of so much consequence, for in both cases the ultimate effect is to raise and lower the centre of oscillation.

The comparison of the small sliding weight serving to regulate a pendulum does not well apply to the circumstances in contemplation. It is true that any alteration of the place of that weight, either up or down the rod, will influence the rate in a different way, when this weight is over or under the centre of oscillation. But suppose the jars of my pendulum to reach from the bottom to the top of the pendulum; will not the centre of oscillation be in the middle of its length then? and will it not remain there if the compensation is correctly calculated? It is always the centre of the mercury column which must be considered, and not the top of it, if we speak of the compensating effect,

"Clyde" further finds that the mercurial pendulum with a glass rod comes nearest to the theoretical pendulum—"a heavy point suspended by an immaterial line;" and he finds this a virtue. I am also inclined to prefer simplicity, but it seems to me that any attempt to invent a compensating pendulum would be useless, if no allowance on this point could be granted. A gridiron pendulum with nine brass and steel rods is at least as far from the ideal as the one proposed by me.

Thirdly, "Clyde" refutes my claims as to the reduction of the resistance of the air to the least amount. I will not contradict Galileo's theory, but I fancy the situation of a body falling from the top of the Leaning Tower, in the open air, is somewhat different from that of a pendulum bob vibrating through the narrow enclosure of a clock-case, though I willingly admit that both these movements are emanations of the same source of gravity.

It is a grave error of "Clyde," after calculating that my mercury jars have a total surface of 160 square inches, and Graham's jar only 43.4 square inches, in stating the resistance to the motion of bodies to a fluid medium is in the ratio of their surface. It has always been admitted as an undeniable fact, that *the shape* of the bodies is in an essential relation to this resistance. If this axiom was not acknowledged, I should conclude that a ball instead of a lens would be the best form for a pendulum bob, since the ball encloses the greatest amount of matter in the smallest surface. And it might also be considered immaterial whether a lens cleaves the air with its edge, or whether it goes through it with its circular face, since the surface of the body remains the same in both cases, etc., etc. This increased surface of mercury jars in contact with the surrounding air is exactly what I aimed at for bringing the mercury to the same condition as the rod, in respect to its susceptibility to changes of temperature.

I am perfectly well aware of the difficulty of improving an instrument so perfect as Graham's pendulum, but this difficulty ought not to be for all time a barrier to any attempt at improvement; and if "Clyde" persists in thinking my arguments erroneous, I hope he will do me the justice to acknowledge that I did not think superficially about this matter, as he gives me to understand, much to my regret.

After further reflection I have not taken out a patent for this pendulum; still I can not, with the best of my ability, see the proposed analogy between a patent pendulum and patent medicine. However, this matter is rather out of connection with the scientific part of the subject; and if I could hope to get a little nearer in accordance with "Clyde" on the pendulum itself, his dissenting opinion on the patent matter would not cast much shadow on the esteem I always feel for those who zealously study the theoretical part of their calling.

M. GROSSMANN.

Glashütte, Saxony.

In June, 1826, a discovery was made of the *chef d'œuvre* of Tompion, which had been so long lost. It was made for the Society of Philosophical Transactions, and was a year-going clock. A record exists which states that Tompion was at work on this clock when the great plague broke out in London, and on the day that he finished it he was attacked by the pestilence. His friends removed him to the Continent, where he died. On the dial was this inscription:—"Sir James Moore caused this movement to be made with great care, anno domini 1676, by Thomas Tompion." Tompion was paid one hundred guineas, and the clock was removed to the society's house, and there in the confusion of the moment it was placed in the lumber room, where it lay without a case exactly a century and a half. One thing wonderful attended this discovery, namely, that all the steel pins on being cleared from dust were found to be as brilliant as ever they had been.

Letters to the Editor.

All letters to be addressed to the Editor, at the Institute, 35, Northampton Square, E.C.

SIR,—It is always a pleasure to read Mr. Grossmann's letters, for, while upholding his own opinions, he never says anything disparaging to his opponent; and, if he is wrong, and it is clearly pointed out to him, he admits his error at once, and renders any discussion, in which he takes part, alike creditable to himself and instructive to his readers, I therfore beg to submit the following remarks upon his letter in the *Journal* for December, in which, after admitting his error in measuring the impulse angles of equi-distant locking pallets from the tangents, states that in circular pallets the error is so small as to be of no consequence. In this he is wrong; for on calculating the angular distance from the tangents of the locking and delivery corners of the pallets when on the periphery of the wheel. I find the outer corners 19′ 41″ and the inner corners 26′ 44″ *within* the tangents, and as the error is double the above, we have 1° 30′—39′ 22″=50′ 38″ as the locking angle of the first pallet, and 1° 30′—53′ 28″=36′ 32″ as that of second pallet. I need scarcely say that the lockings would thus be quite unsafe; in fact, 1° 30′ is a shallow locking.

I would here remark that I think it is much better and a simpler method of drawing circular pallets to draw chords through the locking and delivery points in the periphery of the wheel on both sides, and produce them till they cross each other and the line of centres, the crossing point is the centre of the pallets, and we can measure the locking and impulse angles from the chords (prolonged) with very little trouble and no chance of error, and the calculations are equally simple.

I shall be happy to send you, Mr. Editor, diagrams, with explanations and the necessary calculations, if you can spare the space and think it desirable. Mr. Grossman's method of drawing the locking faces for the "draw" angle is also wrong, but I must keep further remarks, with your permission, for another letter.

Yours, &c.,

JOHN FEWTRELL.

Birmingham.

[**We shall be glad to receive further communications.—ED.**]

SIR,—I am glad that the "Member of the Horological Institute" admits that he made a mistake in his answer to my letter in the *Journal*; still he does not agree with me; and, in fact, he reasons in an opposite direction from the real question. I said in my first letter that I did not wish to reopen the question, "Going-barrel *v.* Fusee." I mentioned the correct going of a going-barrel watch, which was in my possession at the time; I sent the report of its going from the Observatory in Geneva to the Secretary of the Horological Institute, and having often had first-rate results from going-barrel watches, both of my own make and others, I must say, as I said before, "I cannot see any reason why watches should be made with fusee."

To avoid repitition, pray don't ask "if Mr. Lange thinks" this or the other, and do not make it appear as if I by any possibility could have said that in watchmaking it is not necessary to attend to "niceties in construction," I have not said so, and I really don't think that I even could dream it.

As a "Member of the Horological Institute" seems to think that a watch cannot be a good one without a fusee, how comes it that nearly all English keyless watches are made without fusee? Surely some of them are good?

With regard to my friend, Mr. A. P. Walsh, I am sorry that my letter made him sad; his letter makes me sadder. To think that his melancholy is extreme is certainly very sad, but if he will read my letter again, and also look at the report from the Observatory, I hope that he will soon recover his usual genial temper.—Yours,

CHRISTIAN LANGE.

99, Strand.

[**This correspondence must now cease.—ED.**]

MR. PERKINS'S LECTURE.

SIR,—I am at a loss to understand the concluding remarks in the above lecture, as I am credibly informed that the lecturer is not ignorant of the fact that a company is now in existence in Birmingham, which has been established for two years upon the system explained by him, and employing similar, and in some instances superior, machines to those described in the lecture.

My object in writing is not so much to convict the lecturer of misrepresentation, as to inform your readers that such a company not only exists in England, but is in active operation, in proof of which I beg to subscribe myself

A SHAREHOLDER.

P.S.—I enclose my card.

BOARD OF TRADE RETURNS.

Probably no statistics afford a surer indication of the national progress than the relative amounts spent in Watches and Clocks. A comparison of the imports for 1873, and the preceding two years which we subjoin, if we allow for ordinary fluctuations, show neither advance or decline. If, however, we take into consideration the greatly increased number of English watches made during the past two years, many for foreign customers, but a large proportion for the home market, we may fairly conclude that with increased wealth, the people of this country are buying the more durable English work in preference to foreign goods. We trust by another year to be able to sustain this welcome inference in a more pronounced manner.

	Month ending 31st December.			Year ending 31st December.		
	1871.	1872.	1873.	1871.	1872.	1873.
Watches value.	£32,957	£38,924	£43,692	£469,704	£351,150	£407,284
Clocks number	35,331	24,230	36,540	325,667	373,625	403,183
Clocks value.	£42,658	£34,155	£44,638	£373,572	£438,110	£425,741

To Correspondents.

I shall be obliged for replies to the following queries:—How are the dove-tails made for Jewel slips in potence for lever watches? Also the notch in lever for ruby pin, how is it made? Any information will greatly oblige. Is the statement correct which I saw respecting main springs being graduated for English watches? I thought the Fusee was a substitute. I can understand going-barrels wanting them, but not a Fusee Watch.—H. S.

W. Lee.—*When the quarters are struck upon more than two bells they are said to "chime," although the word chime originally referred only to the machinery for automatically playing tunes upon the bell.*

British Horological Institute.

DIARY of MEETINGS for FEB., 1874.

DAY.	DATE	TIME.	BUSINESS.
Monday	2	8.0	Technical Class.
Tuesday	3	8.30	Council.
Thursday	5	8.0	Technical Class.
Monday	9	8.0	Ditto.
Thursday	12	8.0	Technical Class.
Monday	16	8.0	Technical Class.
Thursday	19	8 0	Ditto.
Monday	23	8.0	Ditto.
Thursday	26	8.0	Ditto.
Friday	27	8.30	Finance Committee.

It is by many writers said that the two first clocks known in England were Westminster clock and another at Canterbury, but without doubt the one at St. Paul's preceded both of these. A new great clock for Canterbury is mentioned to have been put up in the year 1292, in the time of Henry III., and to have cost £30. Thus, Dart, in his "History of Canterbury Cathedral," has given, from a manuscript in the Cotton Library, the following extract:—"Anno 1292, Novium orologium magnum in ecclesiâ (Cantuariensi), pretium £30."—For a new large clock for the church (of Canterbury) the sum of £30.

Evelyn, in his "Memoirs," under date 1645, records that while he was at Venice he went "thro' an arch into the famous Piazza of St. Marc. Over this porch stands that admirable clock, celebrated next to that of Strasburg for its many movements; amongst which, about 12 and 6, which are their houres of Ave Maria when all the-towne are on their knees, come forth the 3 Kings led by a starr, and passing by ye image of Christ in his Mother's armes do their reverence, and enter into ye clock by another doore. At the top of this turret another automaton strikes ye quarters. An honest merchant told me that one day walking in the Piazza, he saw the fellow who kept the clock struck with this hammer so forceably, as he was stooping his head neere the bell to mend something amisse at the instant of striking, that being stunn'd he reel'd over the battlements and broke his neck."

THE speech of our President at the Mansion House on Saturday, January 17th, and published in our last number, contains so much that is suggestive and worthy of consideration that we make no apology for again referring to it. Mr. Denison's strictures on prize essays were quite as severe as his remarks on the late exhibition, and, as in the former, so in the latter, the conclusions arrived at are due, for the most part, to a train of false reasoning, founded on a misconception.

Our President, it would seem, has long been of opinion that prize essays are worthless; that they are "almost synonymous with an attempt at finer writing than the author is master of, containing nothing of the smallest value to mankind. What earthly use to anybody can there be (he asks) in encouraging young Watchmakers to waste hours in painfully writing in many pages what may be found in as many lines, and infinitely better done, in various elementary books of science or mathematics."

Now, it is first to be observed that our prize essays are not meant for mere literary exercises, neither are they supposed to be competed for by young men only. In issuing their scheme of competition, the Council appeal to the trade generally, irrespective of age or position, not for finer writing than the author is master of, but for a plain, practical statement of the means whereby certain results are obtained. Many of these results, as in the case of springing and timing, are not deducible from fixed, unalterable laws, and are therefore incapable of mathematical demonstratior. Of course it would be idle to deny that a knowledge of mathematics would assist a springer, in that it would enable him to gain certain ends, by more direct and less painful paths; but it is equally certain that a mastery of all the text books in existence would not of itself enable anyone to acquire the art of springing and adjusting a watch or chronometer.

This art is only to be acquired by a long and diligent apprenticeship in the workroom, and not by the study of elementary books of science and mathematics. The principles of isochronism and adjustment have hitherto been so little known as to constitute one of the secrets of the trade, and young members of the trade, anxious of gaining practical knowledge of these subjects, have been compelled to grope very much in the dark. It was with the view of eliciting practical information of a kind likely to assist such searchers after knowledge that the Council of the Institute conceived the idea of a prize scheme. Having succeeded in placing before the world an essay on the lever escapement, by far the most exhaustive and complete of anything that has yet appeared, they hoped that similar success might be met with in other directions The essays on isochronism undoubtedly fall short of this, but as first efforts, we hold them far from despicable, and we know that to some of our country members they have afforded hints and glimpses of knowledge that have been eagerly welcomed. The value of prize essays in a literary sense, in these days when literature of a general character is so cheap and good, is much open to doubt. But it must be borne in mind that the literature of watchmaking has yet, for the most part, to be written; and we look forward to the time when scientific education, combined with the highest degree of manual cultivation, shall give us horologists capable of imparting their knowledge in a clear and exhaustive manner.

Meantime, we must be content to take the experience of those who have achieved success by a long course of study and experiment. It is to these men that the Council most earnestly appeal. It would indeed be grievous if the great amount of practical knowledge possessed by many of our leading workmen were to perish with them. The dissemination of this knowledge would be a positive step forward scarcely to be overrated. There are no royal roads to proficiency in the art and practice of watchmaking, but let us at least mark the path, so that he who treads it may avoid the many pitfalls and stumbling-blocks with which it at present abounds.

THE HIGHER HOROLOGICAL ART.*

RULES FOR THE CONSTRUCTION OF ASTRONOMICAL, NAUTICAL, AND OTHER EXACT TIME MEASURERS

(By URBAN JURGENSEN.)

(Continued from Page 3.)

The arcs of oscillation would in this manner be only increased $\frac{1}{14}$; the larger arcs would then become, by means of this supposed outward motion of the watch, 187½°, and the smaller arcs 162½°. In the first case the arcs of oscillation would be altered to the extent of 50°; in the second, as the oscillations are twice as quick, their extent would only be altered 25°, from which we may conclude that BY INCREASING THE NUMBER OF THE OSCILLATIONS IN A GIVEN TIME, WHILST THEIR EXTENT REMAINS THE SAME, THE INFLUENCE OF ANY OUTWARD MOTION OF THE WATCH IS DIMINISHED, AND IN GENERAL THE QUICKER THE OSCILLATIONS THE LESS LIKELY ARE THEY TO BE DISTURBED BY THE MOTION OF THE WATCH.

However exact this rule may be, yet the number and quickness of the oscillations of the balance have certain limits, for experience has shown that very quick oscillations increase too much the friction of the different parts of the watch, and that this greatly increased friction soon spoils the machine. From this we find it is better to adopt a mean between the very quick and very slow oscillations, and that we must not make their number greater than is suitable to the solidity and general construction of the watch. Fortunately, experience has taught us the rule which in this matter we should follow, and we can fully accomplish our object by causing the balance to oscillate not less than four, and at most five to six, times in a second. Five oscillations are very well adapted for timekeepers, that have to be carried about, such as watches. Four oscillations are more suitable for those which are much less disturbed—as, for instance, marine chronometers suspended in the ordinary way in gimbals. The extent of the arcs of oscillation differs according to the construction of the escapement with which the timepiece is furnished, but this is a matter which will be treated of further on.

* *Translated from the German, by Mr. George Mayer.*

Friction of the Pivots and Means of Reducing it to the Lowest Degree.

Before I give the appropriate methods for reducing the balance pivots to the lowest possible degree it is necessary to make clear what we understand by the term MOMENTUM. In the motion of the balance we have two subjects to consider; the one is the mass, or the weight of the balance; the other is its velocity. THE MASS MULTIPLIED BY THE SQUARE OF THE VELOCITY GIVES THE MOMENTUM. This momentum must be as great as possible, in consideration of the frictional resistance of the pivots. It is by means of the momentum of the balance that the friction of the balance pivots is overcome. We can in two different ways cause the balance to have the same momentum—either by giving it a great weight and small diameter or a larger diameter and less weight or mass. The diameter determines the velocity of a point in the circumference of the balance, and this point would have a velocity twice as great as a point in the circumference of another balance, whose diameter would be half the diameter of the first balance, and which would vibrate through the same number of degrees as the first one. We can thus express the velocity by the diameter. If we suppose that the weight of a balance be 16, and that the velocity be also 16, then we should have as the momentum, $16 \times 16^2 = 4{,}096$. If we further suppose the weight of another balance to equal 4, and the velocity 32, we should then still have the same momentum, $4 \times 32^2 = 4{,}096$. We know that the friction is in proportion to the surface upon which a body moves multiplied by its mass or weight. If we suppose that both the large and the small balance oscillate through 360°, then the motion of the pivots in their holes would in each case be the same, and so far the friction would also be the same. It is then only the weight of the balance which makes any difference in the friction of the pivots. We have supposed the weight of the large balance to be 4, and that of the small one 16, and so the proportion of the friction of the larger balance to that of the smaller is as 4 : 16, or 1 : 4; that is to say, the friction of the larger balance is

ess than that of the smaller, from ›e that a balance of a large dia- small weight causes less friction ›r balance of greater weight and neter, the momentum in each case ıme.

preceding it will be seen that it isable to employ a very small it would be necessary to increase to such a considerable degree in ain the required momentum, and increase the friction to an inju- ; on the other hand, it is not at that the balance should be so light mentum is obtained by means of inary diameter. Such a balance have the necessary stability, and more like a fan acting upon the ıe regulator of a timepiece. Between ctremes there is a mean, the just- ch is proved by experiment, and he dimensions of the balances of :eepers whose performance is the e an easy and certain guide.

ıter or less friction of the pivots ınce depends not alone upon the ıe balance, but also upon the con- e pivots themselves and the holes hey work. The thickness of the : hardness, polish, and length; the which the holes are made; the the oil which we must employ, ›portion between the diameter of ıd the holes; all these produce more :ion. Whilst we are not able to friction of the pivots, we can at such measures as will render this :onstant and unchangeable as pos- ›e measures are as follows:—

.vots to be made as thin as their ll allow, for, as the friction of the ı proportion to their diameters, ıeters produce less friction.

.vots to be perfectly smooth, well ıd very hard, so that they may polish.

ıivots to work in jewels of the ıe, as sapphire or Oriental ruby.

nds of the pivots to work upon ard stone; and in the case of a nometer, or other timepiece, which ı a horizontal position, the end of pivot should run upon a good flat lished diamond.

ıivots must have oil, in order to e friction and avoid wear and rust.

:eat possible freedom of the oscil- :he balance and constancy of the ıch takes place, and which we cannot avoid, are of the highest importance in a watch. Nothing conduces so much to its perfection as jewel holes for the pivots of the balance, but it is above all of importance that these jewel holes should be well formed, so that the oil can remain at the place where the parts rub together; also that they should retain their smoothness. Fig. 14 shows a jewel hole with its end piece; *a* is the stone, in the middle of which the pivot hole is drilled; this stone is fastened in a brass setting *d*, the stone *a*, is convex upon that side which is in contact with the end piece *b*, and this end piece is also in a brass setting, as is shown at *c*. The flat side of the jewel hole is furnished with a sink for the oil, and the hole itself is very short; it is not much deeper than it is wide. This hole is not quite cylindrical, but narrower in the middle than at each end, as is shown on a larger scale in Fig. 15.

Fig. 14.

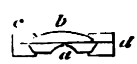


Fig. 15.

By these means the oil which has lost its fluidity, and the dirt which might gather at the holes would not be so great a hindrance, and the edges of the holes, being farther away, could not injure the pivots, as happens sometimes when the holes are cylindrical and the sharp edges are but slightly rounded off. The upper side of the stone does not require a counter sink, it is all-sufficient if the edge of the hole is rounded off a little. The end stone *b* must nearly touch the convex side of the jewel hole *a*. Between the jewel hole and the end piece there must be but very little space. In this way the oil, which is between the end piece and the convex side of the jewel hole, will by capillary attraction be retained in its place ready to enter the pivot hole as the oil in the counter sink dries up. The oil has a great influence upon the regularity of the watch. One kind of oil will become thick and dry up; another will injuriously act upon the metals; and in both cases the effects are bad. Attempts have been made to improve the oil, and I have tried a great number of these preparations, but the result is, I have come to the conclusion that pure natural oil, such as we obtain from very ripe olives by making cuts in them and without pressing them much, is the very best that can be employed for the purposes of horology. This I would recommend above all other oils, but it is not easy to get. For pocket and marine chronometers oil is not necessary for the escapement, and this is a great gain, only the pivots must be carefully oiled; and if

those of the balance and escape wheel are made very fine, and the preceding rules are attended to, the action of the oil will be reduced, so that, even if we have not the very best oil, that which we are compelled to use will affect in a less degree the regular performance of the timepiece. Above all, when it is impossible entirely to avoid an evil a great deal is won if we are able to diminish its injurious influence.

It is, as we have remarked, necessary that the balance pivots should be well finished; that is, sufficiently hard and highly polished. The most suitable form for these pivots is that which we see in Fig. 16, where is shown a portion of a balance axis ending in a pivot. The axis and the pivot are in this figure considerably enlarged, in order more clearly to show their right shape. The pivot has no shoulder, but its greatest diameter is equal to that of the axis (balance staff), and it becomes thinner from that part to the point, which works in the jewel hole, and which is almost cylindrical. This pivot is not quite conical, but somewhat hollowed out, as is shown in the figure. If we finish the pivot in this manner we make it very strong, however fine may be the part which works in the jewel hole. It is of great importance to make the diameter of the pivot less than that of the hole, so that the oil, which sooner or later will become less fluid, shall not interfere with the free movement of the pivot in the jewel. The general rule, which has the most useful results, for the ratio of the diameter of the small pivots to the size of the holes, is, that THE DIAMETER OF THE PIVOT SHOULD BE ONE-SIXTH LESS THAN THAT OF THE HOLE.

Fig. 16.

When the pivots are larger, as in marine chronometers hung in gimbals, a play of one-seventh thediameter of the hole will be sufficient.

The balance spring might interfere with the free motion of the balance if it were applied in such a way as to press the pivots against the sides of the holes. In order to avoid this we must take care that the centres of the balance spring and of the balance are in exactly the same place, and that the balance spring when fastened in the stud retains its natural form, and neither presses to the one side or the other. It is only the skilful and practised artist that is able properly to apply a balance spring—a thing which is of the greatest importance—for the balance spring, as we shall presently see, may be held to be the *soul of the* watch.

OF THE RESISTANCE OF THE AIR.

WE have seen that in the construction of the pendulum diminishing the resistance of the air is by no means unimportant; it must follow that it is of still more consequence in the balance; for while this has a far higher velocity, it has less mass with which to overcome the resistance; and, therefore, would be more affected by the air than the pendulum would be. Nevertheless, we cannot make this resistance of the air altogether inconsiderable, as the only means of doing this would be by giving the balance a very small diameter; but we have already seen that reducing the diameter increases the friction, the effect of which is much more objectionable than is the resistance of the air.

Fortunately, the density of the air does not alter very much, and so cannot cause any remarkable irregularity in the going of the watch.* But as it is not for us to diminish the resistance of the air by reducing the diameter of the balance or the extent of its oscillations, we can do no more than give to the balance (the diameter and velocity of which are already determined) the most suitable shape, so that the surrounding air may affect it as little as possible. To do this we must make the arms of the balance sharp, the better to cut through the air.

Further, we must make the balance ring-shaped, for in this way it will have the greatest weight or mass and the smallest resisting surface. Upon the same principle it must be made of a metal possessing the greatest specific gravity. Platinum would in this respect be the best; after platinum, gold; and after gold, brass. As for the compensation balance, it suffers much more resistance from the air than does the ordinary balance, and it is just the compensation balance to which we cannot devote too much care for the purpose of diminishing, or almost entirely obviating, every possible disturbing cause. All that in this respect we are able to do is, so to construct the different parts of the balance that it will cut the air with the least possible resistance.

When the friction of the balance pivots and the resistance of the air are diminished as much as possible, we shall have done a great deal towards perfecting the balance for the purpose of measuring time; but we yet have to deal with the influence of temperature—of heat and cold—a source of great irregularities. The following section will treat of this detrimental influence, as also of the methods of compensating for, or equalising it.

* At the conclusion of this subject we shall return to the question of the resistance of the air to the balance. See also the appendix, "On the action of the air upon the balances of chronometers."

NOTICE OF THE ELDER BREGUET.

THE following interesting notice of the celebrated Breguet appeared in the *Edinburgh Review*, vol. 32, p. 370, for 1819. The book mentioned is entitled, "*De l'Industrie Française: par Monsieur Le Compte Chaptal, Ancien Ministre de l'Interieur, &c.*"

"The mechanical arts, which Mr. Chaptal mentions as having been so much improved during the last thirty years, are generally importations from England. They may be classed under two heads — commercial and scientific. Among the former our spinning machines stand out the most prominent. Among the latter the first which is mentioned is watchmaking; and the name that is justly pre-eminent is Breguet. We are glad of an opportunity of doing justice to a person of such extraordinary merit. Mr. Breguet is unquestionably the person of the present age who has had the greatest number of happy inspirations on the art which he cultivates. His inventions are as numerous as they are brilliant, and every branch of Horology is rich with the traces of his inventions; but Mr. Breguet, to his own loss and to the detriment of science, was placed too much within the reach of a futile market, where the profoundness and justness of his views were not generally appreciated, and his thoughts were unconsciously thrown out of the channel to which his own genius would have directed them. The sublime art of Horology we conceive to be the exact measure of time for the scientific and commercial purposes of astronomy, geography, and navigation; but in France the public is of another opinion, and the chronometrical part is neglected for others which are merely ornamental, or else intended as a personal convenience and *jouissance* to the proprietor. Persons, for instance, who, to borrow an expression from the *Almanach des Gourmands*, '*se vouent à la carriere des indigestions*,' find as much gratification, when tossing away the sleepless hours of a heated night, from having a repeater by their bedsides, as the captain of an English man-of-war might do, when tossing on the Atlantic, from being able to reckon his longitude; and the striking part of a watch, as well as that which shows the more bulky portions of time, the days of the week, of the month, and often the month itself, is particularly well executed in France. As much ingenuity may be displayed by the artist who gives perfection to the one as to the other of these systems; but our attention to the philosophical part is a corollary of the constant anxiety we show toward great enterprises, toward the promotion of useful knowledge, and the discoveries and pursuits which enlarge the views, and better the condition of mankind; while the superiority of the French in a branch of Horology which cannot be of the slightest assistance to the advancement of knowledge or the progress of the world, proceeds from their being more wrapt up in luxurious and selfish gratifications. With the demands of such customers Mr. Breguet has been too much forced to comply, and we cannot but regret that so much ingenuity should have been diverted from a worthier object.

"Mr. Breguet, however, has not neglected astronomical clocks and watches, and the few which he has been called upon to make are admirably executed and distinguished by original improvements. It is only the more ludicrous, however, that all the inventions for which Mr. Chaptal gives him credit in this art are things which have long been in common use in England—the detached escapement, the cylindrical balance spring, and the compound balance; while he actually omits all notice of his many undoubted discoveries. Among these, and many others might have been quoted, are, first, the *parachute*, to prevent the pivot of the balance from breaking, should the watch fall, and which is convenient for pocket watches; second, the *tourbillon*, by means of which the balance, beside its vibratory motion, performs a revolution upon its own axis in a certain time, in such a manner that, supposing the chronometer to be in a given position, each point of the balance has successively been uppermost at the moment of rest, and any inequalities in its weight, or defects in centering, are compensated during each revolution; third, an escapement which he calls natural, and which requires no oil; and, fourth, a double escapement. We cannot compliment Mr. Chaptal on his knowledge of Horology.

"Mr. Breguet has lately executed an idea which is worthy of the greatness of England, but which he must not look to find recompensed in France. He has made *a number of marine timepieces* on the same principles and of the same dimensions, in such a manner that the homologous parts of any one of them will fit into all the others. The escapement he has adopted is that of Earnshaw; but it forms a system in itself, and, without any preparation, can be taken out of one watch and put into another by merely loosening two screws; insomuch that, should an accident happen to one, another can be put in its place in less than five minutes. The natural escapement Mr. Breguet has not yet made public. The double escapement is merely a double watch with two escapements and two balances to regulate it; and its effects are very powerful in correcting errors. The same idea has also been ap-

plied to clocks, to which a second pendulum is added; and Mr. Breguet has already collected some very interesting facts upon the transmission of motion by bodies which are themselves at rest, at least as much as human hands can make them.

"No person, as might have been expected, is more disposed than Mr. Breguet to do justice to the superior state of Horology in England; and he accordingly prefers importing from this country the most delicate parts of his most precious and improved chronometers. An English artist of great merit and modesty (Mr. Molyneux) has, to our knowledge, furnished him, within the last four years, with a number of escapements, compound balances, &c., which we conceive to be fully equal to the demand of the French market. It is no disparagement to Mr. Breguet that he uses foreign elements in his machines, as his is all the merit of the adjustment and finish; but he pays no small homage to this country in thus practically acknowledging our elements to be the best.

"Mr. Breguet, who is a native of Switzerland, not of France, is the only artist in that kingdom who can be ranked with our Arnolds, Earnshaws, Harolys, &c., and with the numberless others who daily make the most accurate instruments for measuring time, not only in London, but in many other cities of the United Kingdom. The great profusion of these machines which are used in our navy, royal and commercial, the number of them that are in the hands of persons who cultivate science as an amusement, who honour it, and who are proud to be honoured by it, is perhaps the thing which best illustrates the vast pre-eminence which England enjoys by the joint diffusion of wealth and science among her enlightened population. There was a time when France had her Le Roys and her Berthouds, but we had our Harrisons, our Ellicots, and our Mudges; and, if ever the former did make timepieces as well as in England, they never made one quarter of the number. We are confident that during the last thirty years, as well as at this moment, for every chronometer that has been made in France, two hundred, at least of equal goodness, have been manufactured in England. It is a very rare occurrence to find a watch of this description in France, except in the hands of an academic astronomer; and the ruling taste of the country is to prefer the toy to the machine, the trinket to the instrument. For gilded clocks most beautifully executed, and at every price, and for pretty watches, the French, as Mr. Chaptal says, have no competitors. * * * * *

"An instrument, which we cannot pass by in silence, and for which the astronomical world is indebted to Mr. Breguet, is the following. In the focus of a celestial eye-glass two hands, like those of a watch, are seen to pass, with an uninterrupted motion; and, in their passage, to correspond to the divisions of an unmoveable circle, seen also in the field of the eye-glass. The correspondence of these hands, with the divisions of the circle, mark seconds and tenths of seconds; and, as the eye can follow them at the same time that it observes the star, which goes through the field of the telescope in the same direction, the duration of its passage can be determined with much more accuracy than by the usual method. What is further remarkable in this instrument is that an uninterrupted motion is produced by means of an escapement. One of the wheels which communicates motion to the hands has a round hole in the centre and is held upon a round arbor by means of a spiral spring, the central point of which is fixed to the arbor, and the other extremity to the wheels. The vibrations of the balance are very rapid, and keep the spring in a continual state of nearly equal tension; by means of which the motion proceeds without any visible interruption, although seen through a powerful lens." * * * * *

"Mr. Breguet has lately established a transit instrument for better observing his chronometers. From our own personal acquaintance, we know of eight watchmakers in London, who have transit instruments—and there probably are more."

A PATENT has been recently obtained in France for obtaining alloys of iron with manganese, titanium, tungsten, silicium, &c. According to the *Revue Industrielle* scrap iron and iron turnings and filings, or iron sponge coarsely pulverised, are mixed with minerals containing the maganese, tungsten, titanium, or silicium, also pulverised, in suitable proportions, and moistened uniformly and completely with an ammoniacal or an acid solution, after which the mass is compressed in moulds. Great evolution of heat takes place, and in a few hours a hard compact mass results, which is broken into fragments with a sledge. These fragments do not disaggregate at the temperature of melting iron. They are used in a peculiarly constructed high furnace, and when reduced yield excellent alloys. The ferro-manganese contains at pleasure from 20 to 75 per cent. manganese, and in the same way ferro-silicium containing 22 per cent. of silicium has been obtained. Alloys of titanium and tungsten, or of all combined, are readily procurable. The temperature required is very high.

DELHI CLOCK TOWER.

THE Municipal Commissioners of Delhi have effected many improvements in that city since the mutinies: the streets are now amongst the cleanest and best drained, and repaired, of any native city in the upper provinces.

The latest improvement is the new clock-tower, which stands in the centre of the Chandnee Chowk, opposite the Town Hall. Of this a photograph is given in "Professional Papers of Indian Engineering."*

This building is erected on an appropriate site at the crossing of four streets, and stands 110ft. high, exclusive of the gilt vane and finial. The lowest storey is about 20ft. square externally. The materials used in its construction are brick, red and yellow sandstone, and white marble. The capitals surmounting the main corner pillars are 4ft. 2in. wide at top, and 4ft. 6in. deep; they are carved out of solid blocks of white sandstone, and each of them weighs about two tons.

The dials of the clock are sufficiently elevated to be visible from the East Indian Railway Station and from other prominent points in the city. The clock is constructed to work five bells, placed in the open canopy above it; these give out a different peal for each quarter, the largest bell striking the hours.

The building was completed in eighteen months, at a cost, including clock and bells, of 28,000 rupees, the whole of which amount was provided from municipal funds.

The following was the specification for the clock and bells:—

"The bells to be fixed above the dials, with a clear open space round them, in order to let out the sound. The hammers to be very strongly screwed to the beams of the bell-frame, the largest hammer to the largest bell, care to be taken that they do not touch the bells when at rest, but yet give it a good firm blow when in action. The bell-frame to be constructed as shown on plans, with a sufficient space between it and the walls to afford room for the descent of the weights.

"Immediately below the bell, and on a level with the centre of the dials, will be fixed the bevel wheel work.

Behind each dial screwed to a shelf will be placed one of the motion works, communicating with the bevel wheel work by a rod. Below this will come the movement of the clock, raised above the floor on a stool about 3ft. high, and connected by a rod with the bevel wheels above. The single hammer-tail at one end of the clock should then be connected with the largest hammer, which strikes on the largest bell (No. 5). The hammer-tail at back of clock (the back of clock is where the pendulum swings) will be connected with No. 4 bell; the next tail to it with No. 3, and so on.

"The hour-striking part and the going part each takes 48 turns to go for eight days, the chime part 75 turns. Double lines should be used, as shown on diagram. The striking part takes one 8-inch weight and 4 shifters, the going part a small weight and 2 small shifters, the chime part one 8-inch weight and 9 shifters; as 75ft. cannot conveniently be obtained for the fall of the quarter weights, this part of the clock will have to be wound twice a week. A distance of 50ft., down which the going and striking weights can descend, will be sufficient to enable those two parts to perform for eight days."

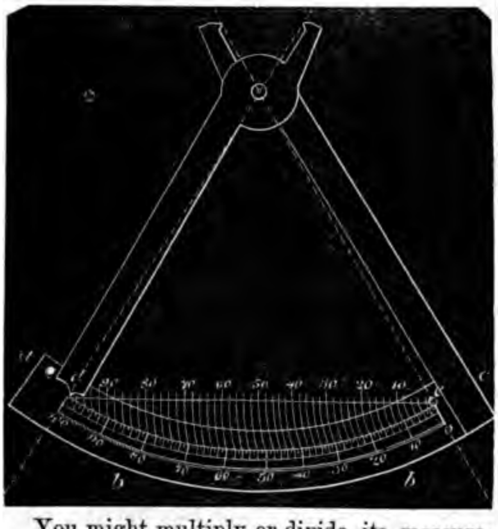
* No. VIII. Edited by Major A. M. Lang, R.E. Printed and published at the Thomason College Press, Roorkee.

A PATENT has been obtained by M. Pirsch-Baudvin for a metallic alloy, which is declared to resemble silver better than any other yet known with respect to colour, specific gravity, malleability, ductibility, sound, and other characteristics. The new alloy is a compound of copper, nickel, tin, zinc, cobalt, and iron. The following proportions are said to produce a very white metal, perfectly imitating silver:—Copper, 71·00 parts; nickel, 16·50 parts; cobalt, 1·75 parts; tin, 2·50 parts; iron, 1·25 parts; zinc, 7·00 parts. A small quantity of aluminium, about 1½ per cent., may be added. The manufacture is rather peculiar. The first step is to alloy the nickel with its own weight of the copper and the zinc in the proportion of six parts to ten of copper. The nickel alloy, the iron, the rest of the copper, the cobalt, in the form of black oxide, and charcoal are then placed all together in a plumbago crucible. This is then covered over with charcoal and exposed to great heat. When the whole is melted the heat is allowed to subside, and the alloy of zinc and copper is added when the temperature is just sufficient to melt it. This done, the crucible is taken off the fire and its contents stirred with a hazel stick; the tin is then added, first being wrapped in paper, and then dropped into the crucible. The alloy is again stirred and finally poured into the moulds; it is now ready to be rolled and wrought just like silver. A great portion of the zinc is volatilised in the act of fusion, so that a very little remains in the alloy. The superiority of this metal is said to depend principally on the cobalt, to which is due its peculiar argentine lustre.

THE "OUTIL AUX DOUZIEMES."

I have been again pondering over the remarks made by Mr. Frodsham, on the "Twelfth's Tool," (see *Horological Journal*, November, 1872), the truth of which are too evident to admit of contradiction. Still, I cannot help thinking that if the tool could be made to measure as correctly with the scale marked on a *fixed arc of a circle* as with the scale in the instrument described in the sketch in the above number of *Journal*, it would be practically better; because the less moveable pieces in a measuring tool the less liability of error from loose joints, &c., and, besides, the pressure of the spring (d) on the scale e, however light when the limbs are wide open, must of necessity become greater on the end of moveable limb when nearly or quite closed, and I am afraid that this friction would interfere with the necessary delicacy of pressure when measuring some slight piece of work—a lever escape wheel, for instance.

I enclose a very rude sketch of a tool with a fixed scale, the measurements marked on a circular arc, but in which, I believe, the error can scarcely be said to exist at all.



You might multiply or divide its measurements within reasonable limits, and find no greater error than would be likely to occur in the *practical* use of the other tool.

The only part of the sketch that I beg to call attention to is the scale, and the method of dividing it; a b c is the scale. The straight line from a to e is the chord of the whole arc embraced by the instrument when quite open (just 60 degrees, though the angle is of no consequence, so that it is not too great); this straight line is supposed to be divided into 100 equal parts. (50 such divisions are shown.)

The circular scale is also divided into 100 parts, all shown, but instead of these divisions being each a one-hundredth part of the whole arc, or, in other words, instead of dividing it into 100 equal parts, the divisions on the straight line d e are set off on the scale each one from the point e as a centre. The fifty small arcs cutting the line d e, and reaching to the curved line on the scale, will explain what I mean. The only error that I can see that could possibly arise from the scale would be when a measurement happened to contain an odd fraction of a division (say 90½ divisions), but this error, being due to the difference between the length of the arc contained between divisions 90 and 91, and the chord of such arc (which is about 1 degree), would be so extremely small that I very much question whether any ordinary measuring tool would detect the error. I believe it would be less than a thousandth part of one division.

My own opinion about it is that, although not absolutely perfect in theory, it would be found in practice quite as correct as the one pictured in the number of *Journal* I have referred to. I should be sorry to say anything disparaging of that tool, and should be glad to have the opinions (for and against) of those who know more about these matters than I do.

If the method I have tried to explain contains anything new, I think the only wonder about it is that it has not been thought of before.

It may be as well just to remark that unless the edges of the jaws (where the actual measurement is taken) are perfectly sharp edges, a very slight imperfection must arise, in consequence of the circular motion of the jaws, but this applies to all tools of this class alike. I have a notion that a correction might be applied to remove that error, without any more moveable pieces, or any great extra difficulty in the using.

J. VIRGO.

Sundridge, Kent.

GREAT efforts are, says the *Swiss Times*, being made at Winterthur to establish the manufacture of watches. It is estimated that, if successful, a sum of 300,000 francs per annum will be distributed in wages, and that the industry will be represented by a yearly return of one millions of francs, drawn from foreign countries for the manufactured article.

THE DIAMOND AND OTHER PRECIOUS STONES.

By M. BABINET, of the Institute of France.

(From the "Smithsonian Report" for 1870.)

(*Continued from Page* 45.)

ɪrt of making diamonds has been almost ʒerly sought as that of producing gold. ıroblems are not, however, the same in ple, since to make a diamond is simply ystallize carbon or charcoal, while in cing gold the alchymists attempted to e the very nature of bodies, and to make f all things. Modern chemistry having the diamond, and discovered that the ct of its combustion is the same as that ıed by the burning of charcoal, we l suppose that some peculiar compound arcoal might be found which, submitted h process as would allow the carbon to ıte very slowly in a condition of perfect ss, would produce regular crystalline

is thus that sugar, salt, and alum are de- d when the water which held them in on is evaporated very slowly and in t stillness. Looking at it in this light, is a curious substance which renders the iment of diamond-making a hopeful mat- It is not generally known that in com- g sulphur and carbon a colorless liquid duced resembling water, and containing nothing but sulphur and carbon. If by process the sulphur could be got rid of, wholly or partially, we might expect to he carbon deposited in the crystalline So far this hope has failed. Many plans have also failed, so that at this he crystallization of charcoal is by most as a thing despaired of. Despretz, a er of the Institute, was, however, of a ent opinion. By means of the voltaic y he has obtained on a thread of platina crystalline depositions, which, by their ınd hardness, seem to be really embryonic nds. These crystals, or rather, let us hese particles of diamond dust, have ısed in polishing hard stones, in the same r as ordinary diamond powder. The ific question is then solved. But this ous and sagacious academician did not ıere. He organized, as we may say, eds of preparations to facilitate the pre- ion and aid crystallization of charcoal under the influence of electricity, an agent which in the researches of man is the obedient servant of his will. These interesting facts lead us to indulge the hope that persevering and sagacious labor will be rewarded by success in the crystallization of carbon and the manufacture of the diamond. Although this result might not be advantageous to commerce, it would be so to science. Nowhere does nature show us the diamond in the locality where it has been formed; it is now only obtained from ground which has changed its place, so that we get no light on the primitive conditions of its crystallization, a circumstance which seems to confirm the views of Despretz, which is, that in Brazil, side by side with the diamond, there occurs a curious substance as hard as the diamond, which is called by the Portuguese *carbonado*, and in trade at Paris *carbone*. Speaking of the mines of Brazil, Tennant says of it: "There is found here a considerable quantity of a black substance of the same specific gravity as the diamond, laminated, or rather, composed of a succession of laminella generally broken into separate fragments. It is too imperfectly crystallized to be cut, though it possesses in places the brilliance of the diamond, and can be reduced to powder for the polishing of other stones. Its name, *carbonado*, is due to its having an appearance resembling charcoal. May not this be the same substance as that artificially obtained by Despretz? In the age of Louis XIV it was thought that it was quite possible to increase the size of diamonds by placing them in certain solutions, just as a piece of salt may be increased in size by placing it in a solution of the same substance. Despretz has, doubtless, considered the property that a crystal possesses of attracting and regularly arranging around itself particles of matter analogous to its own. At present this is the whole scientific condition of the subject. Let us wait for future developments.

Several years ago the premature announcement of the artificial production of diamonds agitated all Paris. Baron Thenard, however, by an experimental examination reassured the many merchants and families who had been alarmed on account of the threatened depreciation of their fortunes, based on the value of this queen of gems. Since this time the

number of diamonds has increased in France, and is every day increasing, even more rapidly than in England, and now represents an immense capital. According to the remark of Archard, there is no article which, being resold, suffers so little loss, so little depreciation, while at the same time it is always in demand. It may almost be considered a circulating medium for high values. Furthermore, in the actual state of physics and chemistry, nothing warrants the fear that the artificial will ever compete with the natural product. The case is analogous to the well-known production of the gold pieces made by M. Sage, from gold extracted from the ashes of certain burned vegetable substances, a beautiful scientific result, but by no means lucrative, since every piece of 20 francs cost 125 francs in the making.

In like manner, we may say that if the process were known, the artificial gem would cost more than its worth.

The other precious stones have been designated "colored gems." In fact, their principal merit is the beauty of color and play of light which distinguish them, but to this we may add hardness, which insures their preservation, and which is one of the most important qualities that a precious stone can possess. Pliny says that in gems we see all the majesty of nature united in a small space, and that in no other of her works does she present anything more admirable. According to him, the first one who wore a precious stone was the Titan Prometheus. Released from his bonds and impressed by some ideal sentiment, he inserted in a piece of his chain a fragment of the rock to which he had been fastened, and thus formed a ring, which he ever after wore in memory of his misfortunes Is there not some allegorical sense in this story of the construction of the first ring? What leads us to this supposition is the mysterious personage himself who is made the wearer. This grand personage, Prometheus, the benefactor of man, who gave him fire stolen from the gods, has always been venerated in antiquity for his opposition to the imperious domination of Jupiter.

The ancients included also, under the name of gems, stones engraven either in relief or in intaglio, and in this form of art they have left us the most admirable productions that the imagination can conceive. Here, as in sculpture, the moderns have neither surpassed, nor even attained to the perfection of, the works of antiquity. Engraven stones, which were used as seals, are now the most precious and valuable of relics, while they afford us definite mineralogical ideas as to the various kinds of ornamental stones known from the leariest period of history.

Stones of color do not probably, at the present day, represent more than one-tenth of the total value of gems, while diamonds may be estimated as ninety per cent. This was different among the ancients. With them the diamond was hardly known as an ornamental jewel, because it was uncut, and did not exhibit those vivid colors which now place it in the highest rank among precious stones. Furthermore, our system of lighting with lamps, gas, or candles, throws upon. all object tints very unfavourable to the natural color of gems. Thus the garnet, turquoise, amethyst, and even the opal, lose much of their lustre in these artificial lights. When a colored stone is placed in the path of the solar spectrum its color will vary with the portion of the spectrum which falls upon it, and two stones of the same color, but of a different nature, will exhibit different effects. Thus a paste, placed beside a fine colored stone, betrays its worthlessness. A simpler method of testing stones is to look at them through a bit of glass colored red, yellow, blue, or green. Every stone will exhibit under this test properties peculiar to itself and by which its nature may be recognized.

Since we have spoken of paste, I would remark that, in spite of the high price of fine stones, there are fewer false ones used than at first we should be inclined to believe. Paste, colored or not, is only a very fine glass, overcharged with lead and enamel, analogous to the best quality of cutglass for table service. In the early times of its substitution for precious stones it was cut very carefully; now it has become common and cheap and inferior in workmanship. Besides, national riches augmenting from day to day, and the insufficiency of paste for beauty and duration becoming more and more apparent, a greater expense for something of imperishable value is preferred to a less price paid for what is really an article of no permanent worth. We are now long past the time when the Duchess of Berri, arriving in France, received for her bridal ornaments only paste, and when, in order to make the Duke of Wellington a present in diamonds of less than a million francs in value, the Paris trade was obliged to borrow from the civil list a certain number, guaranteeing their restitution in kind.

Before speaking of colored stones a question presents itself: Can science explain the coloring of these gems? There are, I suppose, few persons who do not know that the white light which reaches us from the sun and other heavenly bodies can be decomposed into a number of colored rays. Thus, when the light of the sun passes through a triangular prism, it is bent, and will trace on a white

card placed opposite to it an iridescent band, in which Newton has marked seven colors, according to some idea of analogy with the seven notes of a musical octave; an idea which is, after all, without foundation, since every prism gives its own peculiar band. The idea was by no means new. The Greeks and Romans entertained it, and Nero, who in dying pitied the world for losing so great an artist as himself, has sung it in verse. A child blowing a soap-bubble produces colors as splendid. In a word, every thin plate of any transparent substance whatever becomes colored under white light. Striated surfaces also offer effects not less brilliant; so that, to clothe certain insects more vividly, nature has grooved the tissue that envelopes them. The globules of clouds between us and the moon produce also, with white light, the most vivid colors; and, above all in beauty, the *iris* or rainbow, which the sun paints in a thousand colors in the drops of the falling shower, is the transcendent effect of decomposed light. Nature always, with a palette, so to speak, charged only with white, knows the art of spreading over all her pictures the magic and glow of the most brilliant coloring. But we have not exhausted all the resources of this coloring, the secret of which is the light itself. How shall we explain the whiteness of the snow, which covers our planet at either pole, and on the summits of the loftiest mountains? How account for the perpetual greenness of countries covered with planets and trees, the blue of the vast aerial sea which envelopes the earth, or the color of the great ocean which rests on its surface? Here science is in default. The cause of the color proper to bodies is only half perceived; and we can say still that which Huyghens said at the end of the seventeenth century, "In spite of the labors of Newton, no one has yet fully discovered the cause of the color of bodies." We must then admire, without penetrating their secret, the unparalleled red of the oriental ruby, the pure yellow of the topaz, the unmingled greenness of the emerald, the soft blue of the sapphire, and the rich violet of the amethyst. This is not the only thing the discovery of which we shall leave to posterity.

In the enumeration that follows we shall place the precious stones in the order of their actual value. This order varies little in different parts of the world. When an extraordinary demand, however, occurs, that causes a rise in price of any particular gem, there flows into the market such an overplus of that gem that a fall in value is at once effected. This is the case at present with the beautiful Hungarian opal, which in the last ten years has become abundant, the mines producing it being more actively worked on account of the high price of these stones, which for a while has surpassed that of the sapphire. The oriental *ruby* is, for its price as well as its beauty, the first in rank among colored stones. In order to appreciate its color in its finest quality we must compare it with the blood as it spurts from an artery, or the red ray in the solar spectrum. It is the pure red on the painter's palette, without any admixture, on the one side of orange, or on the other of violet. Many of the stained-glass windows in our ancient churches, when traversed by the rays of light, give this color in its brilliance. The ruby is excessively hard, and, after the sapphire, which surpasses it a little in this respect, is the first of stones, always excepting the diamond, to which there is nothing at all comparable. According to a perfectly just remark of M. Charles Achard, more competent than any one in France to give an opinion touching the trade in colored stones, there is a great difference between these and the diamond, which, from the minutest specimens to those of princely or sovereign size, have a fixed price proportioned to their weight, as is the case with gold and silver. As for rubies and other gems, the very small specimens have hardly any value, and it is only when of some weight that they command high prices. Rubies are, therefore, much used for watch pivots, and, from their abunbance, are of little value; but for a ruby of 5 carats double the price of a diamond of the same weight will be paid. If the ruby weighs 10 carats triple the value of a diamond of the same weight may be asked for it; which price would be about 20,000 to 25,000 francs. All the world admits that a perfect ruby is the rarest of all the productions of nature. Its tint shows to the same advantage by day as by lamp light; but to render the color more resplendent it should be placed in the midst of the red rays of the spectrum in such a manner that the rest of the colors do not fall very near it. The possessors of choice collections of stones can repeat this interesting experiment with various stones, placing each in that color of the spectrum which is analogous to that of the stone itself. It is a severe test for the purity of the tint; for, if pure and unmixed, the stone will appear completely black in every other light but its own. Milky and turbid stones cannot bear this test.

When Pegu was annexed to the British East Indian Possessions it was thought that that country, so rich in rubies, would send many of these stones, so jealously guarded by the Indian princes, into the European market. Such has not been the case. It is not yet proven, however, that the ruby mines are still

worked; and this part of Asia is the least known of all the countries of the globe. Merchants in rubies will never cease expatiation on the number of tigers, lions, elephants, and venomous serpents, which people the forests and the plains of this country, which, according to them, is only accessible by the openings of the rivers from the sea. The actual state of the island of Borneo, as authentically given, seems very much to confirm these rather interested accounts. I do not know that the rajahs attach a superstitious importance to the possession of rubies, but it is certain that they never sell any of considerable weight. With the *Koh-i-noor*, Runjeet Singh possessed a no less precious ruby, which was of the shape of the large end of an egg that had been cut in two. This enormous gem made a part of the necklace of this prince, and was estimated by him, without any fear of finding a purchaser, at 12,500,000 pounds sterling—about as much as 300,000,000 francs. We know nothing of the quality or weight of this ruby, which has not yet been brought to England. The ruby is, with the sapphire, the zircon, and the garnet, one of the heaviest of stones. In water it loses only about the fourth of its weight.

The Indian princes set their beautiful rubies in the collet of a ring, somewhat elevated, and surround them by several rows of small diamonds, so that the whole produces a kind of disproportionate elevation, contrary to our ideas of good taste, which admit but a single stone in a simple French setting, the stone not too prominent—for example, in diamonds, a solitaire of three or four carats.

The composition of rubies is no less extraordinary than that of the diamond. Like the sapphire, the ruby is nothing more than a bit of crystallized earth, colored by iron, which naturalists call the painter of nature. It is not too much to repeat the strange assertion, that nature has made the most precious stones with the most common materials; we will say that this kind of earth, called *aluminium* or clay, and the white pebble or rock crystal, called *silica*, or flint, forms the base of nearly all gems. Opal is rock crystal with water. Topaz joins a little fluoric acid to silex and aluminium. The emerald, the crysolite, the aqua-marine, the tourmaline, and the eulase contain another element besides silex and aluminium, viz: *glucine*. Finally, garnet is so ferruginous that it acts on the magnetic needle. The zircon, a stone very little esteemed in France, has for base a peculiar kind of earth called *zircone*.

As accessory to the ruby, we may mention a stone less deeply red in colour, called the *spinelle ruby*. The crystalline form of this differs from that of the oriental ruby, which is a six-sided cylinder, cut squarely at both ends; while the spinelle is, like the diamond, a double pyramid. The name of *balass ruby* has been given to a stone of Magal, which several authors regard as a real oriental ruby, only having a less rich color. The ancients did not apply the name ruby to this stone. It is called by Pliny *carbuncule* (incandescent of coal), and by Ovid and the poets *pyrope*, or that which has the color of fire—

Flammas imitante pyrope.

With us the word carbuncle is little used except to describe a ruby of considerable size. Pliny has evidently confounded the Indian ruby with the garnet, which is found everywhere. Certain rubies cut spherically—a form which is called *calotte spherique*, tallow drop, or *cabochon*—present in the middle of their red tint a white six-rayed star, which changes with the position of the eye and forms in the sunlight a beautiful spectacle. This effect is called *asterie*. It is found also in the sapphire, a near relation of the ruby; like it, being composed of aluminium, and colored by iron, differing only in its color, which is blue, while that of the ruby is the most vivid and purest red.

Next in rank to the ruby we place the *emerald*, of which Pliny says no gem has a color so agreeable. This stone, which comes to us from Peru and New Grenada, is very soft, hardly scratching rock crystal. It is found in beautiful green crystals, implanted and produced in a kind of freestone of a whitish color; and we can comprehend no cause other than electricity for such a deposit as that of the emerald in the midst of a stone differing both in nature and in color from this gem. Nero, who was near-sighted, used an emerald, hollowed on both sides, through which to look at the games in the amphitheatres. This was doubtless the first approach to spectacles, since this invention does not date very far back.

The emerald, like the ruby, is a six-sided prism and squarely cut at the ends. This stone is very light, losing in water more than one-third of its weight. Its tint is so lovely that we overlook its want of hardness, which might properly almost exclude it from the rank of distinguished gems. At the time of the conquest of Peru a magnificent emerald was sent in homage to the Pope; and several years afterward the emerald mines there were said to be exhausted or lost. About twenty years ago the principal of a large establishment in Paris, M. Mention, received from South America some magnificent specimens, which quite revived the emerald trade, con-

tinued since without interruption by Charles Achard. The deeper the hue of the emerald the more it is esteemed. It is the largest end of the crystal that is the most strongly colored. The emerald loses none of its brilliance in artificial light; a valuable property in our modern society, where all great reunions are held at night. Haüy includes in the emerald family the aqua-marine and the beryl, one of a greenish blue, the other yellow, but both being like the emerald in form and chemical composition.

The emerald, as well as all stones whose color we wish to develop, should be cut with a flat upper surface, surrounded by retreating facets, continued all the way underneath. The Orientals cut them in broad, thin plates, which, apparently, ought to show the colors of the stone to the best advantage; but the reflection of white light from the large upper surface becoming mingled with that which traverses the gem, renders the hues of the latter less discernible. This is the reason why they are not cut with a table and surrounded by facets; for thus in avoiding a large reflecting upper surface the stone is made to exhibit its fundamental color throughout its whole extent. The emerald, though much cheaper than the beautiful ruby, is nevertheless much admired and sought for. We might almost call it a "stone of general affection," so much is it esteemed by the many.

The *sapphire*, which comes after the emerald, is the hardest of colored stones. It may be considered as a blue ruby, or the ruby as a red sapphire. With Haüy and Mawe, we can say that aluminium is susceptible of crystallizing in almost all colors. The mineralogical species to which the sapphire belongs is called the *corindon*. After the red *corindon*, or *oriental ruby*, comes the blue *corindon*, or *oriental sapphire*. Sometimes the *corindon* is of a beautiful yellow color; then it is called *oriental topaz*. More rarely it is of a violet hue; then it takes the name of *oriental amethyst*. Finally, it may be perfectly colorless, like rock crystal, when it greatly resembles the diamond, with which it is sometimes confounded, but by its greater weight and its double refraction it may be easily distinguished.

By the microscope there may be discovered in certain pale sapphires traces in the direction of the faces of six-sided prisms. The light reflected by these internal filaments produces three small brilliant traces transversely to the filaments and to the faces of the prism. The crossing of these little bright lines forms within the stone a six-pointed star, which gives to the stone the name of *starry sapphire*. Among the Orientals these stones are highly esteemed, especially when they exhibit the star in a ground of deep blue. Corindons of all colors are susceptible of being thus marked. In his voyages in Africa M. Abbadie wore a blue starry sapphire, which often commanded the respect of the natives. There are stars on a red, blue, or yellow ground, according to the color of the corindon. As yet, this phenomenon has never been seen in the white sapphire. I have just said that this reflection arises from little filaments within the stone. These may result either from some foreign substance or from minute hollows left by the regular disposition of the particles at the moment of crystallization. If, instead of trying to observe these starry appearances by reflection, the stone is cut so that it can be looked through, then the phenomenon can be easily seen. Unless the stone is of a very perfect crystallization the observer who takes for the point of sight a lighted candle, placed at a moderate distance, will perceive these little luminous lines of light crossing all the series of filaments which the mineral contains. According as the stone has a four or six-sided form, we have a four or six-rayed star, and if the filaments are all in one direction we have a luminous band.

In scratching with the point of a diamond a plate of glass in various directions we produce bands of light of the same number as the traces upon the surface, which are always in a transverse direction to these traces. We can even very simply produce a star in spreading with the finger a little wax or grease upon a plate of thin glass. It is necessary for this that the coating should be very thin so as merely to dull the glass, and that the finger should be moved directly across—for example, from right to left, or from above downward; then, looking through it at a lighted candle, there will be seen a band of white light crossing the direction of the lines of tarnishing. If the same operation is performed in two directions on opposite sides of the glass, then a four-limbed cross will be formed by the two luminous bands which cross each other before the eye.

Ceylon produces a greenish stone traversed by filaments of white amianthus, which is called the *cat's-eye*, and which is usually cut spherically and quite prominent. We see it in a floating band, which comes from the play of light on the lines of amianthus within it. In general with these curious accidents of light exhibited by exceptional stones, the color of the starry radiance should contrast as much as possible with the tone of the stone itself. In simply scratching crossed lines on a beautiful carnelian I have succeeded in producing a white cross on a red ground.

In minerals this starry quality is very valuable, because it reveals the primitive form of the substance in which it is found, and I repeat that by looking through a stone suitably cut we find these luminous transverse bands in a great variety of crystallized minerals.

There is a very hard dust employed in the arts, called *emery*, a powder used in rubbing or grinding down bodies with hard surfaces. This substance is a species of corindon or sapphire, containing a tolerably large proportion of iron, which has been substituted for the aluminium at the time of the formation of the stone. This substitution is quite common in chemistry and mineralogy. It is believed that the Chinese succeed, by patience, in cutting diamonds with emery. This must be very slow work, because the stone of which emery is composed is very much softer than the diamond; it is like sharpening steel by rubbing it on paper or linen. However, if patience can work miracles, it is doubtless reserved for the Chinese to accomplish this result.

We shall place after the sapphire the *opal*, which comes from Hungary and Mexico. The Hungarian opals are much the superior, and have not the disadvantage of deteriorating with time. Some years ago the opal was higher in price than the sapphire; but increase in value inducing a more active working of the mines, the price of opals, beautiful as they are, fell to what we find it at present. For the perfection of an opal it should exhibit all the colors of the solar spectrum, disposed in small spaces, neither too large nor too small, and with no color predominating. The opal is sometimes called the harlequin, in allusion to the great variety of colors which it displays. The substance of the opal is of a milky hue and of a pale greenish tint. This milkiness is generally known by the term *opalescence*. It is the color of water in which a little soap has been dissolved. In order to explain the brilliant colors of the opal, we may imagine in the stone a great number of isolated fissures, of variable width, but always very narrow. Each fissure, according to its width, gives a peculiar tint, similar to the effect produced by pressing two plates of glass together; we may recognize violet, blue, indigo, red, yellow, and green, the last two being exhibited more rarely than the others.

As a proof that the brilliant colors of the opal are due, as we have said, to narrow fissures, similar colors may be produced by partially fracturing, with the blow of a hammer or a wooden mallet, a cube of glass or even a rock crystal. Colors obtained in this way are known in optics by the name of colors of thin plates, and are of the same character as those of flowers, which result from the overlaying of the transparent tissues of which the petals are composed. Herein lies the secret of all their varied hues, from their first opening until their final decay.

Sometimes the opal is colored only in its substance, has not so great a play of light as when it is variously traversed by fissures, and then it is not so much esteemed. Again, it may have extended fissures exhibiting a somewhat changeable single color—red, blue, yellow, or green. The Empress Josephine once paid a very high price for a pair of these stones, it being then the fashion to wear two bracelets exactly alike, and it was quite difficult to get two stones perfectly matched, since the interior disposition of the fissures of the opal, which gives its peculiar play of color, depends entirely upon accident. At present it is only the *harlequin* opals that are much valued, and those of Josephine would not now bring a tenth of their former cost.

Except for ear rings, the opal should be set singly, with or without a surrounding of small brilliants, whose vivid lustres and scintillations contrast favorably with the tints of the opal.

The opal is not a very hard stone. In its chemical composition it is only hydrated quartz—that is, white pebble, combined with water. Heat, expanding its fissures, varies its colors, and pressure obviously produces the same effect. I have thus often changed, without permanent alteration, the colors of a beautiful Hungarian harlequin opal.

Before the revolutionary tempest, in the closing years of the past century, the financier d'Augny possessed a harlequin opal of great beauty. It was a perfect oval, 21 millimeters long, and from 15 to 16 millimeters in breadth. Esteemed as entirely perfect, the stone had a great celebrity. I do not know if d'Augny ran, like the senator Nonius, any risk of proscription during the years of terror; but certainly if he did, it was not on account of his possession of this unparalleled opal; since the wretched tyrants of '93, who sold to foreigners the treasures of St. Denis and of many other churches, for 80,000 francs, did not dream of opals exhibiting all the colors of the rainbow.

The opal of d'Augny, the value of which I have nowhere seen estimated, passed some time ago into the hands of Count Waliski. The opal of Nonius, of the size of a hazel-nut, which he selected from among all his treasures as the companion of his exile, was estimated at 20,000,000 sesterces, which, according to the exact table of M. Dureau de la Malle, in his book on the Political Economy of the Romans, is about 4,000,000 francs.

"STOPPERS.

stops," or "stoppers," as they are are, without a doubt, the worst feature watch jobbing line. When they are t they embitter the jobber's very ce, and make his calling hateful to A friend of mine, who had a regular of them, once told me very feelingly would consider himself a perfectly man if it was not for these stoppers, nt so far out of his way as to compose erses much in dispraise of them, in "jobbers" rhymed in with "stoppers" beautifully. Of all other kinds the Swiss horizontal watches supply the share of stops, and a large proportion are caused by the "sticking" of the . Whether by means of condensed together with atmospheric moisture, or g else, the banking pin in the balance stud certainly contract in time a sticky ce, which, when the balance banks ightly, causes the pin to attach itself stud, and so stops the watch; till, by itself after some time, or by the being moved, it goes on again. Such ints as "My watch loses an hour a or "It stops and goes on again by are, in nine cases out of ten, owing to ise. I have frequently had to correct ult when the watch had just been by some other watchmaker, and had ken back several times, which proves ey were not aware of its existence. probably spent some time uselessly in ng for some other defect, and lost their er into the bargain. Jobbers ought to t a rule never to put a balance into its without carefully scraping pin and stud. ush alone, and even the use of benzine, sufficient to guard against this fault length of time. The contact surfaces in all cases be very small, and flatten-he sides, therefore, be carefully avoided. ld mention that foreign workmen are t to sin against this rule, as on the Con- owing to the different climate, these tions are less necessary and habitually ted.

A JOBBER.

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he Museum of the Royal United Service tion, Whitehall Yard, is the chronome-t accompanied Captain Cook who was in 1779, in his voyages round the It is a most excellent time-keeper present day.

A Treatise on Watch Work Past and Present. By the Rev. H. L. NELTHROPP, M.A. F.S.A. E. & F. N. Spon, Charing-cross.

ANY effort to awaken a proper appreciation of the mechanical ability represented in the production of watches, and to convey to the general public an accurate knowledge of the principles upon which timekeepers are constructed, will always ensure our warmest sympathy. A comparatively recent work, "Curiosities of Clocks and Watches," by the Rev. E. J. Wood—in which, by-the-bye, there is room for a better chronological arrangement—while giving a tolerably complete history of the progress of the Horological art, leaves room for a work of a more scientific character, having for its purpose the removal of that ignorance respecting the construction of watches, which, as Mr. Nelthropp truly remarks in his preface, at present generally existss. We are reluctantly compelled to confess the present work does not fulfil the purpose indicated. Its arrangement is unnecessarily confused, and a want of clearness in the language renders it difficult to understand at all times what the author really intends to convey; and to make matters wor the diagrams of escapements are so bad drawn as to be of little assistance to the general reader in tracing their action. Some portion of the work, which appears to have been written for the instruction of watchmakers, overstepping the scope of the work, as defined in the preface, and, as might have been expected, abounding with erroneous notions, might with advantage be eliminated. Mr. Nelthropp appears to be unaware that classes "to instil the first principles into the heads of the apprentices" are carried on at the British Horological Institute. We invite Mr. Nelthropp to study the diagrams executed by some of the pupils, which are, at the time we write, displayed upon the walls of the class room, before reproducing upon the covers of the next edition of his work the abortion purporting to represent the lever escapement, which is impressed upon the outside of the book before us.

Two persons belonging to a neighbouring town, being on a visit at Glasgow to see the lions, went to the College among other places. On looking up to the clock-dial they were astonished to observe only one hand, which was an hour behind. One of them thinking that nothing could be wrong about the College, observed in a flippant, apologetic tone, "Hoot man, that's naething ova; 'od, man, I've seen our toun clock aught days wrang." Yorkshire men always speak of a clock as "she."

British Horological Institute.

DIARY OF MEETINGS FOR MAR., 1874.

DAY.	DATE	TIME.	BUSINESS.
Monday	2	8.0	Technical Class.
Tuesday	3	8.30	Council.
Thursday	5	8.0	Technical Class.
Monday	9	8.0	Ditto.
Thursday	12	8.0	Technical Class.
Monday	16	8.0	Technical Class.
Thursday	19	8.0	Ditto.
Monday	23	8.0	Ditto.
Thursday	26	8.0	Ditto.
Friday	27	8.30	Finance Committee.
Monday	30	8.0	Technical Class.

CORRESPONDENCE.

Sir,—I was surprised to learn from a letter in your last issue that a factory exists in Birmingham for the manufacture of watches by machinery. My object in writing is to ask "A Shareholder" if members of the trade would be allowed a sight of the factory at work. I am sure there are many, besides myself, who would gladly make a trip to Birmingham to be allowed the privilege.

Yours, &c., T. M.

In the month of May a request was received from Col. J. T. Walker, F.R.S., Superintendent of the Great Trigonometrical Survey of India, through the Chairman of the Committee, for provision to be made at the Observatory for vibrating pendulums. In the year 1865 two pendulums lent by the Royal Society for use in India had been vibrated at Kew by the late Capt. Basevi; and it was necessary that these pendulums should be vibrated again on their return, and that at the same time two pendulums obtained from the Imperial Academy of Sciences at St. Petersburg should also be vibrated. The Committee at once complied with the request; and at the expense of the Indian Government preparation was made for the experiments in the south hall on the basement story, by removing for a time the apparatus for testing sextants, and building up from the foundation-arches two solid isolated supports for the Russian clock and pendulum. Capt. Heaviside, R.E., the officer charged with the duty of making the pendulum experiments, arrived in England in July, and, finding all the arrangements satisfactory, at once commenced his experiments, which are still in progress. Endeavours were made, in connexion with the arrangements just mentioned, to obtain an electrical time communication between Kew and the Royal Observatory at Greenwich; but the proposal failed of success.—*Report of the Kew Committee for the Year ending October, 31, 1873.*

To Correspondents.

J. J. P.—*You will find plenty of information in the back volumes of the Journal.*

I shall be obliged if some reader can tell me the best method of hardening case springs, &c., so that they retain their toughness.—G. V. S.

For the information of "H. S," *the notch in lever for ruby pin is made by means of a* "*Lever Notch File,*" *procurable at any tool shop.*—Pivot.

Will some practical watchmaker oblige by stating the best and cheapest kind of transit or other instrument for obtaining time by the sun, adaptable to a country jobber, whose time is very limited?—S. L.

D. Reed.—*Thomas Earnshaw was born at Ashton-under-Lyme in* 1749, *and, there is no doubt, introduced the spring detent without pivots for detached escapement about* 1781, *although this substitution of a single spring for the pivoted detent was also claimed by Arnold.*

I have a good English Lever Watch out of which I can get no regular time, it will either gain or lose. I have had it to pieces several times, but cannot find anything to account for that irregularity, I have put a new hair spring, but it is still the same. Can any of your readers suggest the cause?—C. M.

[*It is quite impossible to state the cause without an examination of the watch. Very probably the balance is out of poise.*]

At p. 127 *of Mr. Denison's treatise o* "*Clocks, Watches, and Bells,*" *directions are given for drawing the three-legged gravity escapement, but no mention is made of the proper size of the lifting pins, and though the escapement is mentioned in many parts of the book, yet this is not once referred to. Could you or any one of your readers, or Mr. Denison himself, kindly inform me whether their diameter has anything to do with the correct performance of the escapement, and, if so, by what rule their proper diameter can be ascertained.*—J. P.

It has been, and still is, a disputed point, which part of the Duplex Escapement ought, and which ought not, to be oiled. It is the opinion of some that the perpendicular teeth of the escape wheel, working in conjunction with the impulse pallet, ought to be, and that the horizontal teeth working with the ruby roller ought not to be oiled. No doubt much can be said on both sides of the question, as men of good reputation in the trade differ on the subject. Will you be kind enough to favour me with your opinion?—An Apprentice.

[*It is generally accepted that only the horizontal teeth require oil.*]

THE HIGHER HOROLOGICAL ART.*

RULES FOR THE CONSTRUCTION OF ASTRONOMICAL, NAUTICAL, AND OTHER EXACT TIME MEASURERS

(BY URBAN JURGENSEN.)

(Continued from Page 100.)

CHAPTER III.—SECTION II.

OF THE REGULATOR. THE INFLUENCE OF HEAT AND COLD UPON THE BALANCE SPRING, AND UPON THE OSCILLATIONS OF THE BALANCE. THE SIMPLE COMPENSATION AT THE BALANCE SPRING.

IN order to understand the action of the compensation at the balance spring it is necessary to be acquainted with the use of the regulator. We know that the quickness of the oscillations of the balance depends upon the strength of the balance spring, and that the stronger the spring the quicker the oscillations of the balance, and the weaker the spring the slower the balance.

The strength of the balance spring depends upon the thickness and breadth of the metal band from which it is made, as well as upon its length. When the thickness and breadth are determined, the strength will be according to the length, so that the strength of a balance spring will be increased by shortening it; on the other hand, it will become weaker by making it longer. In order to obtain a certain number of oscillations of the balance we must apply a balance spring of suitable strength, which will very nearly produce the required number, but to bring about the highest degree of exactness we make use of the regulator, which, by lengthening or diminishing the outer turn of the balance spring, increases or shortens its strength. Fig. 17 shows the balance *a a*, with its balance spring *b*, of which the outer turn is attached to the cock by the stud *o*. The inner turn is fastened to the axis of the balance by a collet. Upon the cock A is seen a raised part *e e*, containing the jewel hole. Upon this the piece *g m*, the index, works with a slight friction, so that the point *m* can describe the arc from F to L. The opposite end *g* will then move in the same line in which lies a portion of the outer turn of the balance spring. Two screws in this raised piece *e e* prevent the index from being lifted off, and these screws at the same time hold in its place the end stone upon which the point of the pivot works. In Fig. 18 the cock is shown from below, with the balance spring in that position which it would have when attached to the balance staff. We see there a portion of the index with the two pins, *m* and *n*, which curb the outer coil of the balance spring; this has but very little play between the pins. We see by Fig. 18 that by moving the index away from *b*, the acting part of the balance spring is decreased, by which means it becomes stronger and produces quicker oscillations.

Fig. 17.

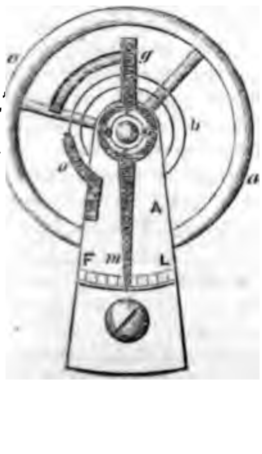
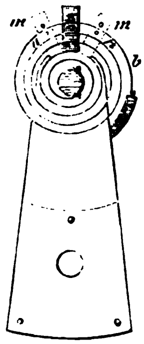


Fig. 18.



If we lengthen the acting part of the balance spring, by moving the index towards *b*, the spring becomes weaker, and the oscillations of the balance slower. In this way, we can, by means of the index or regulator, affect the motion of the balance. The two pins of the index are, as we have remarked, at a very short distance from each other; if the distance is so great that the outer turn of the balance spring does not touch the pins, even during the most extensive oscillations of the balance, then it is clear that the regulator can have no effect upon the spring, and that in proportion as the pins are closer together, so will that effect be greater.

If we suppose that one of those pins is moveable, so that the play of the balance spring can be increased or diminished, it is easy to see that the duration of the oscillations may by that means be influenced, and that they will become quicker when the pins approach nearer to each other; in such manner

* *Translated from the German, by Mr. George Mayer.*

is produced the simple but very ingenious compensation, which we will presently describe.

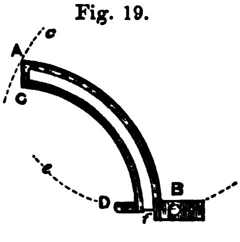
Of the Influence of Heat and Cold upon the Oscillations of the Balance.

The equal duration of the oscillations of a pendulum would be interfered with by the influence of heat and cold, or changes of temperature. To the oscillations of a balance this happens in a much greater degree. The variations in the oscillations of the pendulum would be caused only by the expansion or contraction of the pendulum rod, but the variations in the oscillations of the balance are produced not only by the expansion and contraction of the balance itself, but also from the effect which changes of temperature have upon the balance spring. Heat enlarges the balance and lengthens the balance spring, and these together make the oscillations slower, and cause the watch itself to go slower or lose. Cold brings about the opposite effect; contracts the balance and shortens the balance spring, which make the oscillations faster and accelerate the going of the watch. These alterations are very noticeable, even in ordinary watches, and to such we may with advantage apply the compensation to the balance spring, but in marine chronometers this method is insufficient, and by no means produces that exactness which these machines demand, and which is necessary for determining the longitude. Here we must bring about a complete compensation, which we obtain by means of the balance itself.

Of the simple Compensation of the Balance Spring.

In order to thoroughly understand the action of the compensation applied to the balance spring, it is desirable to consider carefully the effect which heat and cold would have upon two plates joined together. Suppose a rod of brass and one of steel were placed side by side and firmly attached to each other by soldering; then, if this compound bar be submitted to the action of heat, both metals will expand; but we know that brass expands very much more than steel, and so our compound bar would bend over to the side of the steel, supposing that one end of the bar were moveable and the other left free. If we submit the bar to the influence of cold, the opposite effect will take place. The motion of such a bar is remarkable: to prove which we need only to hold one in the flame of a spirit lamp, and the bending immediately becomes very apparent. If we give to our compound rod the form *A B C D*, Fig. 19, and make the outside of steel and the inside of brass, and fix the end *B* so that it cannot move from its place, the part *A* would, by the effect of heat, bend towards *c*, by which means the part *D* would get nearer to *e*; but as the heat equally affects that portion from *C* to *D*, the end *D* will approach still nearer to *e*, so that the entire motion will be considerably more, or less, according to the degree of temperature to which *A B C D* is submitted. The direction of *D's* motion when *A B C D* is influenced by cold is the opposite of its direction in the preceding case, and *D* will move towards *f*, or, what is the same, will get nearer to *B*; whilst heat will drive it from *B*. By the action of heat *A B C D* will open, and by that of cold will shut. We know that less play between the pins of the regulator will cause the oscillations to be quicker, and a greater play will cause them to be slower; therefore, if we apply the compensation *A B C D* to an index, so that the part *B* is fixed by means of a screw and steady pin, and the part *D* remains free to move, it is easy to see that the play of the balance spring would be altered accordingly as the changes of temperature altered the compensation. By means of heat *D* would get nearer the fixed pin *e*, and the balance spring would have less play. The contrary would be caused by cold, the balance spring having more play. The action of heat upon the balance and the balance spring, which makes the oscillations slower, would be compensated by the closing of the regulator. The action of cold, which makes the oscillations quicker, would in an equal degree be compensated, inasmuch as one pin would recede from the other, and they would thus become more open. This compensation works, as we here see, in a very simple manner, and can in every case be applied with advantage where it is only a question of an approach to exactness, which, nevertheless, is much greater than we can expect from the ordinary watches in general use.

Fig. 19.



We have been favoured by Mr. M. Tanenburg, the honorary secretary, with a copy of the rules of the Leeds and District Watchmakers' and Jewellers' Association, having for its objects the promotion "of one uniform scale of charges for repairs" and "the protection of the trade generally." We wish the association every success, and shall always be glad to receive reports of their proceedings.

ON BELLS, AND MODERN IMPROVEMENTS FOR CHIMING AND CARILLONS.

[A Paper read before the Members of the Society of Arts. *]

By GEORGE LUND, Esq.

I feel that some words of apology are due from me for presuming to read a paper before so learned a society as this; but upon the scientific part of the question I most candidly admit that I am not equal to entering at present, being quite content to quote the opinions of others far more competent than I to express an opinion; but I venture to think that upon the practical part of the bell question, and the mechanical means used for producing the best musical effects upon them, I may be heard with pleasure and interest by my audience generally; and to some of my hearers, who, like myself, are enthusiastic in such matters, I may be able to impart some information which may prove of value in furthering the common object we have in view, the revival of the love of bell music, which, until within the last few years, has fallen considerably in public estimation, on account of the rude and unsatisfactory machinery used in its production. I propose to divide the subject of this paper into three heads, giving, firstly, some information about what came under my notice while making a hurried tour through Belgium, the home of chimes; then, secondly, touching briefly upon bells, their manufacture and uses in our own country, to come, thirdly, to the more immediate subject of this paper—hemispherical bells, and modern improvements in the machinery of chimes and carillons. The first town of importance on the route, viâ Dover, Calais, and Cologne, is Ghent, where there are 44 bells, a tune being played every quarter of an hour, once an hour being not enough to satisfy the insatiable desire of the Belgians for bell music. My impression on first hearing them was, that they were played, by some means, loud and soft, but I soon decided that that could not be without a system of dampers being used, and that I knew had not, and has not yet been successfully, if at all, applied to bells. It is a subject to which I intend to give attention as soon as possible, and I hope any difficulties, should damping be found to be useful, may be overcome. I must say I do not believe it to be a Herculean task. We have already sketched out a very simple method of damping by apparatus attached to the hammer, which could be easily altered to be worked by a pedal or by an extra key, so that a bell could be allowed to sound out for any length of time or damped instantly; and I have no doubt that most intricate and difficult effects of melodies, with running accompaniments in the bass, could be played in this way with perfect distinctness, the great fault with all the Belgian music being its indistinctness.

The machinery used in Ghent is on the same principle as in all the other towns, and is the same as has been used in England till within the last few years. A large barrel of either iron or brass, with pins in it of large size to catch upon the ends of the levers, to which are attached the hammers which strike the bells, to raise them, and let them fall again immediately on the bell, is driven by a smaller drum and wheel, round which is wound the flax or iron wire rope, to which is attached the weight, which is the motive power. At Ghent the music drum is made of brass, with square holes punched into it, and in these holes iron lifting-pins are placed. The surface of the barrel being divided by the square holes into intervals for crotchets, quavers, and semi-quavers, it is a matter of no great difficulty to arrange the tunes, and when it is desired to remove them for a change of tune it is easy to knock them out from the inside, and to put them in such other holes as the nature of the notes to be produced may require. The ropes here are of flax; the driving weight is 300lbs., and is wound up twice a day. There are as many as four hammers to some of the bells, and none have less than three. The brass drum is about six feet in diameter, and when in motion reminds one very much of a water wheel, so ponderous does all the machinery look. It was constructed by Charles Nolet, a native of the town, and I have no doubt his fellow townsmen are very proud of his memory, for he must have been long since dead. The next place *en route* is Bruges, where the machinery is on a much larger scale than even at Ghent, the barrel being eight feet in diameter, 48 bells, and as many as six hammers to some of the bells—190 in all. The machinery was constructed by Antomusde de Hondt, of Bruges, as far back as 1748, and of late years

* From the "Society of Arts Journal."

iron wire has been substituted for flax rope. The weight has to be wound up every two hours, a man living in the tower for that purpose. The clock here is worthy of passing notice, being of a very large size, to carry the hands for the dials, which are 19 feet in diameter. It has a gridiron pendulum, which is supposed to compensate for changes of temperature, but this it certainly does not do to any satisfactory extent. It strikes the hours at the hour and half hour, on a different bell at the half hour to distinguish them, and a tune is played at each quarter. As at Ghent there are small clappers fixed inside the bells, by which they are played upon by hand. The performance is done in this way : The man who is about to distinguish himself regularly prepares as for a pugilistic encounter. He takes off his coat, waistcoat, and hat, puts his long hair learnedly off his forehead and behind his ears—at least, the man I saw did—looks intently for a few moments into the corner of the room, puts on a regular pair of boxing-gloves in the greatest possible hurry, evidently for fear that the brilliant melody should escape him, sits himself down in front of long rows of pegs and pedals, and bangs away at them as hard as ever he can go, first up, then down, now in the middle, now both ends at once—and I believe the whole lot would have gone down at once if he could have managed it—legs and arms all going in a perfect frenzy, but, there being many more pegs than arms and legs, he could not manage more than a certain number at a time. How thankful the Antwerpers ought to be. Now for the result produced—a great deal of clatter and fatigue, but very little music. Noise and jingle, most lovely to those who like it; but I am one of those unappreciative sort of people, who do not think that music consists in a thundering noise and clatter. Dr. Gatty, in his "History of the Bell," says, upon this subject:—"The Carilloneur uses both hands and feet in executing the sprightly airs which charm the inhabitants of the cities of the Low Countries. The pedals communicate with the larger bells for the bass; and the keys upon which the treble notes depend are struck by the hand edgeways, the little finger of the player being defended by a thick leathern stall. It requires considerable strength, as well as celerity and skill, in the player, for, unless a violent blow be given to the key, only a weak sound would be produced;" and Dr. Burney (in his "Present State of Music in Germany, 1772") says:—"The want of something to stop the vibration of each bell at the pleasure of the player, like the valves of an organ, is an intolerable defect to a cultivated ear, for by the notes of one passage perpetually running into another everything is so inarticulate and confused as to occasion a very disagreeable jargon." He also says:—"The carillons are said to be originally of Alost, in this country (that is, Germany), and are still here and in Holland in their greatest perfection."

The next town I visited where there are chimes was Antwerp, where there are 48 bells. The bells are swung as well as chimed on by the machinery, which was made by Von Hoof, in 1786. The weight is wound up twice a day. These people seem very fond of winding up weights; nothing less than twice a day suits them, and in one instance named every two hours. The next and last in my route was Namur, where there are 54 bells. The machinery was made by Nolet, of Ghent; of the date I have no note, but I should say it was decidedly more recent than the machine by the same maker at his native town, the whole arrangement of the bells and hammers and machinery being much more perfect and mechanical. The music was taken in excellent time; there was a distinct melody runing all through, with a most judiciously arranged accompaniment in the bass.

There is at Louvain a large bell foundry where I believe nearly, if not all, the Belgian bells have been cast. Van Acholdt is the proprietor. At the time I visited him he had nothing particular in hand, but a few years ago he sent a large peal of forty-two bells to this country for Boston, in Lincolnshire which are considered to be very good. The process of manufacture of English bells, which I am now about to describe, will apply equally to the German bells, and I need only mention here that many people consider them superior in tone to ours. I believe that a great deal of this apparent superiority is due to the number they use. Take them singly, and undoubtedly they are thin in quality of tone.

There is a most excellent work about bells, edited by the Rev. H. T. Ellacombe, and called the "Bells of the Church," a supplement to the "Church Bells of Devon," and I was so much struck with the easily-understood description he gives there of bell founding that I think I cannot do better than give it in his own words. He says:—"It will be interesting to the general reader if I describe the modern process of bell casting. This I am better enabled to do by taking the establishment at Whitechapel, the oldest in London or in England." Before describing the process of casting a bell it may be well to state that bell-metal consists of an amalgam of copper and tin, in proportion of about three parts of copper to one of tin. There are, of course, various trade secrets as to the exact

proportions of the different metals necessary to constitute a first-rate alloy. Mr. Denison in his book says that, after many experiments, he has come to the conclusion that the proper composition for bells is thirteen of copper to four of tin.

There is no great mystery after all in the bell founder's art, but extreme care is necessary, in order to produce a good toned bell, that all the preliminary operations should be conducted with the greatest exactness. Passing through various yards at the Whitechapel Foundry—in which are stored quantities of old timber, old bell-metal, and a multitude of odds and ends, in the shape of cannon and great masses of old copper, destined one day for the furnace—we arrive at the moulding room. In describing the casting of a bell it will be necessary to observe that it is nothing more than a layer of metal which has been run into the space between the mould and its outer covering, and allowed to cool. Here we have a section of a bell as it lies in the pit during the process of casting. The various parts of a bell may be described as a body, or barrel; the clapper, or striker, hanging on the inside; and the ear, or cannon, on its top or crown, by which it is hung in its chosen position in the tower.

The following description applies to all bells, large and small, the various modifications in the shape, &c., not interfering with the principle on which it is manufactured. The first principle to be observed is the construction of the shape or form of the future bell, so as to ensure that due harmony in all the parts which shall give to it the proper degree of tone and vibration. Various theories have obtained in different countries, and among the different founders of our own country as to the best proportions for bells; but the following scale has been proposed and generally followed at this foundry as coming nearest to perfection. Taking the thickness of the sound-bow or brim—that is, the part where the clapper strikes—a bell should measure in diameter at the mouth, fifteen brims; in height to the shoulder, twelve brims; and in width to the shoulder, seven and a-half brims, or half the width of the mouth. These proportions, however, are very variable, and depend greatly on the taste, experience, and skill of the founder, an approximation merely being arrived at in these figures. Mr. Denison says: "The most essential point of all to be attended to in ordering bells is to require absolutely, and in spite of all protestation of the founders, that none of them when finished are to be thinner in the sound-bow, or thickest part, than one-thirteenth of the diameter." I know that some good old bells are a little thinner, but I never saw a new one that was less, and had at the same time anything of the soft and sweet tone which church bells ought to have. I can only account for the old ones bearing to be thinner, though by no means so thin as many modern ones, by the well-known greater softness and toughness of the copper of old times, when they smelted less metal out of the ore. The small bells of a peal are always rightly made thicker in proportion than the large ones, and will run up one-eleventh of the diameter, the large ones being one-thirteenth. I would here observe that Mr. Denison goes most minutely into the why and the wherefore of the proportions of metal and the shape of bells; but I have selected Mr. Ellacombe's description of bell founding because I have thought it would be more generally understood. To the searcher after information both books are invaluable, one treating exhaustively on the constructive part, and only slightly on what I may call the archæological part of the question; and the other exhaustively on the archæological, and only slightly on the constructive. I believe that Mr. Denison is at issue with some of the bell founders about the proportions and shapes; but that his theory is a right one seems entirely borne out by the fact that many most excellent peals of bells have been constructed under his instructions, and that he is consulted in almost every matter of importance. The size and proportions, then, of the future bell being ascertained, the making of the mould is proceeded with. The outer form of the core, by which the inner shape of the bell is determined, is made by means of a crook, which is made to revolve on the clay, &c., of which the mould is composed. This crook is a kind of double compass, the outer leg of which is in two parts, formed of wood and metal. The inner part (of metal) is cut or curved to the shape of the outside of the core, or inside of the intended bell; and the outer part (of wood) to the form the outside of the bell is to be made. This crook and compass is made to move on a pivot affixed to a beam above, and its lower end is driven into the ground. In the case of very large bells the mould is perfected in the pit in which they are to be cast. The crook is driven by the hand of the moulder, and the moulds being composed of plastic clay, &c., the form of the inner side of the bell is defined by a few revolutions of this simple machine. Thus is formed the core, or inner mould. The cope, or outer mould, is formed in much the same way, except that its inner surface is smoothed to form the outer side of the bell. The core is first roughly built up of brickwork, with a hollow in the centre. It is then plastered

over with soft clay, &c., and moulded as described, by the action of the crook, and is afterwards dried by means of a fire in the hollow mentioned. When baked sufficiently hard it is covered all over with a size of tan and grease. Over this size a coating of hay bands and loam is laid, the exact thickness the bell is intended to be made; on this thickness the outer leg of the crook—the inner leg which formed the core having been removed—is made to rotate, and so forms the shape of the inside of the cope, or outer mould. This thickening being thoroughly dried, upon it is formed the cope, or outer mould, upon the outer surface of which are formed ledges, by means of which, when dry, it is raised, and the thickening destroyed. Both are then retouched, any device or inscription being impressed upon the inside of the cope; it is re-lowered, and the hollow space between the cope and core is, of course, the exact shape the bell is to be. The head and staple to hold the clapper being now fitted above all, the mould may be said to be complete. A sufficient number of moulds being now formed for the number of bells to be cast, the pit is filled in with earth, firmly rammed down to prevent the copes rising when the metal is run in. The furnaces are now lighted, the metals in their proper proportion are melted—some times as much as twenty tons at a time—and from time to time tested, till found to be of the right temperature, when the furnace doors are opened, and the molten metal directed through properly constructed channels to each mould in succession, till the whole number of bells is cast. Sufficient time is allowed for cooling. The earth is dug away from around the moulds, which are then destroyed, the bells being taken to the tuning room, where they are tried for note; and when tuning is necessary, which is almost always the case, the bell is securely fixed into a wooden frame by means of wedges, underneath a steam cutter, which cuts as much as may be required, either from the inside of the bell in the region of the sound-bow to deepen the note, or from the edge of the lip to sharpen it.

The earliest notice of a belfry and peal of bells is contained in the following passage:—Egelric, Abbot of Croyland (who died 984), in the time of Edgar, caused a peal of bells to be made for his abbey, to each of which he gave names, which it is needless to give here; and the celebrated "Benedictional of St. Ethelwold," in the library of the Duke of Devonshire, furnishes us with an earlier instance of a belfry with four bells, namely, about the year 980. From that time to the present bells of all sizes, shapes, and weights have been cast, and I think that a few moments may not be unpleasantly spent in enumerating some of the most famous. The largest bell in England is, as you are doubtless aware, "Big Ben," the clock bell at Westminster; it may not be equally well known that it derives its name from the fact that Sir Benjamin Hall was the Chief Commissioner of Her Majesty's Office of Works when the bell was first cast, and his name inscribed on it. It was named after him Ben, and from its size was naturally called big; hence the name, "Big Ben." It bears this inscription: "This bell, weighing 13 tons, 10 cwt., 3 qrs., 15 lbs., was cast by George Mears, of Whitechapel, for the clock of the Houses of Parliament, under the direction of Edward Beckett Denison, Esq., Q.C., in the 21st year of the reign of Queen Victoria, and in the year of our Lord 1858." It was contracted for that the bell should bear the blow of an 8 cwt. hammer, but after the clock had struck on it for a few months cracks showed themselves, and upon examination it was found that the metal was porous, and the casting defective. The striking was then removed to the fourth quarter bell, upon which the hours were struck for two or three years; but, after many complaints of the confusion, the striking on the big bell was resumed (November, 1863) with a lighter hammer, the bell being turned a quarter round the button or mushroom head by which it is hung. The four quarter bells were cast by Messrs. Warner without any known defect, and are remarkably good. I may here give you some information which may be new to you, and at the same time bear testimony to the remarkable time-keeping of the clock. We receive from the Royal Observatory at Greenwich by electric current a time signal every hour—and I show upon the table the instrument we use for registering it—having found it extremely inconvenient to be on the lookout exactly at the hour, failing which the signal was lost. It is the invention of a brother of mine, improved by myself only to this extent, that instead of using an ink chronograph watch we use a stop chronograph; and, for the information of those who do not know the difference between the two, I would say that in one the seconds hand is double, and that when the signal comes it draws the upper hand through the reservoir of ink in the end of the lower hand, and so marks the error of the watch on its dial or face, and that the hand is constantly moving. In our chronograph the hand can be started from zero and allowed to travel as long as desired, can be stopped, and again be brought to zero for another start, each being done by pressure. Having placed the hand at rest we put the watch into the instrument, and leave

it. At the next hour the signal is sent from the Royal Observatory, and the hand of the watch is started absolutely to Greenwich mean time. We can then at our leisure compare our regulators. The wire through which our signals come is used by the Westminster clock once each day to transmit a register of its time to the Astronomer Royal at Greenwich, and to Mr. Dent, in the Strand. When we want to compare "Big Ben" we only replace our watch, and let the clock signal (being the second pressure) stop the hand. Whenever it stops to the right or left of zero so is it fast or slow of time. If it stops at zero it is, of course, correct time. It is very rarely indeed that we find it many seconds out. The next largest bell in England is "Peter of York," diameter 8ft. 4in., height 7ft. 7in., weight 12 tons 10 cwt.; the note is F sharp. The next great bell is the "Mighty Tom" of Oxford, 7ft. 12in. in diameter, and weighing 7 tons 12 cwt. The note is generally considered to be A, but, being faulty in some parts, the tones vary, and some say it gives out five notes. Rather a cheap way that of getting the effect of a peal of five bells. Three unsuccessful attempts were made to cast it in 1681; twice it wanted metal enough to make out the cannons, and the third time it burst the mould and ran into the ground. It was at last, can I say successfully? cast, with its five notes, by a London bell founder, named Christopher Hodson. In 1682 it was moved from the Church to the Gate House; on the 29th of May, 1684, it first rang out between eight and nine at night, from which time to this a servant tolls it every night at nine, as a signal to all scholars to repair to their respective colleges and halls.

There is a great bell at Lincoln Cathedral, weighing 5 tons 8 cwt.; note A. This and the two quarter bells were cast from the old 1610 bell, and six other bells from the rood tower, called the Lady bells, by Mears, of London, in 1834. St. Paul's Cathedral has a large hour and two smaller quarter bells, none of them anything to boast of, in the south tower. There is, however, in the north tower a bell which bears the inscription:—"Made by Philip Wightman, 1700." The diameter is only 49½ inches, and the thickness 3¼ inches, yet the tone is most deep and sonorous, and I think, for its size, one of the most pleasing to the ear I ever heard. Having had occasion to try it several times, the impression remaining of it is a most pleasing one, which I cannot say of the three other bells; the quarter bells are specially poor and lacking in quality of tone. There are also large bells at Leeds Town Hall, St. Dunstan's, and at Glasgow. One of the latest additions to the large bells in England is at Worcester Cathedral for the new clock to strike on, and for occasional tolling. It is hung on the balance beam principle. The gudgeons or pivots on which the bell moves are wedge-shaped, and roll on hand brasses, very slightly hollowed; the friction is thereby so little that the bell can be tolled by one man with one hand, although it weighs four tons and a half, a lever being attached to the stock, instead of a wheel, which is necessary under some circumstances. It was so tolled for service for the first time by Mr. Denison and the Rev. H. T. Ellacombe, on Sunday, the 17th January, 1869, in the company of the Rev R. Cattley and others, and it is owing to the last-named gentleman's indefatigable efforts that the peal has since been made up to thirteen bells, and machinery provided to play tunes upon them.

I may here be permitted to publicly thank him for his extreme courtesy to me on the occasion of a visit which I lately made to Worcester. Anything more perfect in the way of general arrangement of bell framing to support and carry the bells, of fittings in the bell-ringers' floor, and evidence of heart and soul enthusiasm of the master mind in the work, from floor to roof of the tower, is not to be found. This is no fulsome flattery, but a statement of plain truth, as any person going there can see for themselves. The bells, made by Messrs. Taylor, of Loughborough, are undoubtedly very fine, and the clock, made by Messrs. Joyce, of Whitchurch, is a specimen of English work of the highest order. The chiming machinery for the tunes was made by Messrs. Gillett and Bland, of Croydon.

In Mr. Ellacombe's book much more and most interesting information will be found about big bells in this and other countries, large peals, &c., and, recommending it to your notice, I pass on to "The various uses to which bells have been put." The two most important of these, and the only two which I shall speak of, are change ringing by ringers swinging the bells, and chiming tunes by machinery. Seventy or one hundred years ago ringing was a much more popular and fashionable pastime than it is now. The exact date is uncertain when the art of ringing a number of variations on bells was first practised, but probably about the commencement of the seventeenth century. Long before that date no doubt bells had been rung, but only in rounds, that is, in the same rotation each time. The earliest known record of a ringing society is to be found in a manuscript in the library of All Souls' College, Oxford, entitled, "Orders conceyved and agreed upon by the company exercising the

arte of ringing, knowne and called by the name of the Schollers of Chepezyde, in London, begun and so continued from the second day of February, anno 1603." This society appears to have existed down to 1634. Three years afterwards another society was formed, called the College Youths, records of which exist down to 1755. There is at the present time a society of the same name, which claims relationship, rightly or wrongly it is not necessary here to inquire, with this ancient and aristocratic society. I do not suppose that much harm will be done, either one way or the other; it is enough for my purpose to say that other societies have been formed, too numerous to mention, that some have flourished more or less—the majority I imagine less—some have died natural, and some unnatural, deaths, but still the College Youths, in name at least, exist. The aristocratic element of the society has now, however, given way to respectable tradesmen, clerks in various capacities, and skilled artisans (I quote Mr. Ellacombe's words), with a very fair sprinkling of clergymen, barristers, and gentlemen of no occupation (but bell-ringing, I suppose). They, however, gave most practical proof of the good ringing qualities they possessed in 1862, by ringing, on the 27th April in that year, a true and complete peal of cinques on Stedman's principle, consisting of 8,580 changes, in a most masterly style, in six hours and forty-one minutes, on the noble bells of St. Michael's, Cornhill, being the greatest number of changes ever rung in that method on twelve bells. The number of changes which can be rung upon a given number of bells is something extraordinary, and, should any of my hearers care to inquire into the mysteries of the art, I would recommend them to get a book called "An Introduction to the Early Stages of the Art of Church or Handbell Ringing, for the use of Beginners," by Charles A. W. Troyte. He there gives as the number which can be rung on eight bells 40,320; time required to ring, one day four hours.

On	9 bells,	362,880	Time	10 days 12 hours.
„	10 „	3,628,800	„	105 days.
„	11 „	39,916,800	„	3 years 60 days.
„	12 „	479,001,600	„	37 years 355 days.

It is a most mysterious art. I have tried to master its intricacies so as to be able to write the changes for our chiming barrels, but at present have made very little progress. The book being only an introduction and for the instruction of beginners, what is to follow must be wonderful indeed. I will read you just one chapter as a specimen. In chapter 4 Mr. Troyte says: "Having in the last chapter, I hope, explained the working of the Grandsire method, I now call the learner's attention to the most beautiful of all five bell methods. It is beautiful in its music, and, once learnt, I think not much harder than the Grandsire method. It was invented by a Mr. Fabian Stedman, about the year 1640, and has since then become most justly popular among ringers. The great beauty of it no doubt consists in the two facts, that bells come to lead at back stroke as well as at hand stroke, and that double dodging is always going on behind.

ON OIL.

Good oil is of such importance to horologists that its value cannot be over-estimated. Instances sometimes occur where oil which had long been considered and found good fails to maintain its character, and thereby tempts the watchmaker to try the oil of other makers, often with anything but satisfactory results. I believe that good oil has often been abandoned for worse when the cause of mistrust, instead of being inherent in the oil, has been due to surrounding circumstances.

The late Mr. Vulliamy related the case of George III. keeping his watches in the cedarwood drawers of a cabinet made specially at the Royal Observatory at Kew Gardens, and these watches gave considerable trouble and dissatisfaction till the cause was found to be the exudation from the cedarwood box changing the oil into a gummy mass.

Some time ago a similar case came under my notice. A customer of mine, who kept his stock of watches in the mahogany drawers of his safe, had the best part of his stock failing through sticky oil, and some that had been in stock for a long time were so bad that the balance could not be made to vibrate with the usual shake; the main spring when taken out of the barrel had all the appearance of having been dipped into glue, and could only be properly cleaned in spirits.

Upon complaints being made in Switzerland about the oil the assurance was given that watches in the factory which had the same oil applied had not given any trouble, which made me think that the mahogany wood of which the drawers were made might be the cause. These were, as usual, unpolished within and lined with velvet, and upon being abandoned for the reception of watches the trouble about the oil ceased.

I beg to give this little hint to watchmakers to be on their guard, although it is probable that other kinds of mahogany or other wood may not be found guilty; or is there reason to believe that the wood had not been cut at the proper season?

W. G. SCHOOF.

ON THE PERFORMANCE OF CHRONOMETERS.

In order to show what progress has been made in chronometers, since chronometer making was fairly started by its founder, Earnshaw, we will, below, let the readers of the *Journal* see the going of Earnshaw's chronometers, and the gradual progress that has been made up to the present time, and the readers may after this look upon things as progressing most satisfactorily. The chronometers selected for this purpose are the two which were tried at the Royal Observatory by order of the Board of Longitude, the daily rates of which are published by Earnshaw himself in his appeal for reward.

Each trial lasted twelve months, and each chronometer was tried three times for twelve months; at the conclusion of these trials Earnshaw received a reward of £3,000. In order to compare the going of Earnshaw's chronometers with those of the present day, it is necessary to divide the trials into the same length as is now adopted at Greenwich, namely, twenty-nine weeks; in order to make each twelve months' trial represent two trials of the present day, twenty-nine weeks are reckoned from the beginning, and twenty-nine weeks from the end. This makes six modern trials for each chronometer, with half a year intervening between each full twelve months' trial. The range of temperature during each twenty-nine weeks is added with the errors as well as the trial number. The trial numbers of these two chronometers are made up in the same way as now adopted at Greenwich, by taking the differences between the highest and least rate added to the greatest change of weekly rate multiplied with two.

Chronometer.—Earnshaw, No. 1.	Chronometer.—Earnshaw, No. 1.	Chronometer.—Earnshaw, No. 1.
1798, Jan. 1st to July 23rd. 15.0 highest and least. 5.6 greatest difference from week to week. (272) trial number. Temperature 35° to 70°. Range 35°.	1798, June 11th to Dec. 24th. 9.7 highest and least. 7.6 greatest difference from week to week. (249) trial number. Temperature 32° to 67°. Range 35°.	1799, Oct. 17th to May 8th, 1800. 17.0 highest and least. 6.2 greatest difference from week to week. (294) trial number. Temperature 20½° to 62°. Range 41½°.
Chronometer.—Earnshaw, No. 1.	Chronometer.—Earnshaw, No. 1.	Chronometer.—Earnshaw, No. 1.
1800, April 3rd to Oct. 16th. 10.2 highest and least. 5.2 greatest difference from week to week. (204) trial number. Temperature 46° to 71°. Range 25°.	1801, July 24th to Feb. 11th, 1802. 36.9 highest and least. 15.5 greatest difference from week to week. (679) trial number. Temperature 26° to 66°. Range 40°.	1802, Jan. 8th to July 29th. 33.6 highest and least. 14.0 greatest difference from week to week. (616) trial number. Temperature 26° to 62°. Range 36°.
Chronometer.—Earnshaw, No. 2.	Chronometer.—Earnshaw, No. 2.	Chronometer.—Earnshaw, No. 2.
1798, Jan. 1st to July 16th. 15.0 highest and least. 5.3 greatest difference from week to week. (256) trial number. Temperature 35° to 70°. Range 35°.	1798, Jan. 11th to Dec. 24th. 49.4 highest and least. 7.0 greatest difference from week to week. (634) trial number. Temperature 35° to 70°. Range 35°.	1799, Oct. 16th to May 8th, 1800. 17.5 highest and least. 12.3 greatest difference from week to week. (421) trial number. Temperature 20° to 62°. Range 42°.
Chronometer.—Earnshaw, No. 2.	Chronometer.—Earnshaw, No. 2.	Chronometer.—Earnshaw, No. 2.
1800, April 3rd to Oct. 16th. 17.1 highest and least. 8.2 greatest difference from week to week. (335) trial number. Temperature 48° to 70°. Range 22°.	1801, July 24th to Feb. 12th, 1802. 11.6 highest and least. 6.2 greatest difference from week to week. (240) trial number. Temperature 26° to 66°. Range 40.	1802, Jan. 15th to July 30th. 12.4 highest and least. 4.2 greatest difference from week to week. (220) trial number. Temperature 26° to 61°. Range 35°.

It will be seen that the mean range of temperature for the early trials is only 35° Fah., as compared with 61° of the present day.

Up to 1835 nothing but the plain balance such as Earnshaw left it had been used, but it was then discovered that this balance had a regular error in extremes, amounting to several seconds, and from that time nothing but auxiliary balances could stand any chance at the Greenwich trials, owing to the trials being not far from twice as severe in temperature as at the beginning of this century. It is satisfactory to see that, whereas formerly the chronometers were not tried in heat but in severe cold and middle temperature, they are now tried in heat such as is experienced in the tropics, and such cold as we experience during the winter in a room without a fire. This in itself is enough to double the error of the ordinary balance. The best trial in 1800 was—

					Trial number.
	° °		"	"	
Tem. 46 to 71 Range 25 only.			10.2	5.2	204
These four years rates have been supplied to us without the temperatures.	in 1840	it was	11.4	4.3	200
	in 1842	„	10.0	4.6	192
	in 1847	„	8.8	5 0	188
	in 1854	„	8.6	4 5	176
Tem. 39 to 100 Range 61	in 1869	„	7 9	4.7	173
Tem. 33 to 96 Range 63	in 1870	„	5.5	3 8	131
Tem. 35 to 96 Range 61	in 1873	„	5.1	3.0	111

The chronometers mentioned here have all been with auxiliary compensation since 1840, excepting the last, which is with Kullbergs flat rim balance, and this is the first instance since the invention of the chronometer that any balance has given such results. If the last four years' rate of improvement should continue we shall soon have arrived at a point where we shall have to remain stationary, because the nearer we get to perfection the greater will be the difficulty.

We call attention to the programme of prizes offered by the Goldsmiths' Company in furtherance of technical education, which is published on the cover of this *Journal.*

Clock and Watchmakers' Asylum.—A special general meeting of the subscribers of this institution will be held at the "Crown and Woolpack," 162, St. John Street-road, E.C., at seven o'clock, on Monday, April 20, when a male inmate will be elected from three candidates:—Thomas Wright, William Schooley, and George Philcox. We are sorry to observe, from the report of the committee for the past year, that the accounts show a balance against the society, which will, however, we trust, be more than made up during the present year.

KEYLESS MECHANISM.

The following is a description of keyless mechanism recently patented by Mr. John Goettler in terms almost identical with his specification:—

The object of the invention is to effect simplicity and economy in the construction of keyless winding arrangements of watches. For this purpose, in order to effect the winding and setting of watches without a key, I employ a short rod projecting through a hole formed for that purpose in the pendant of the watch, and having applied on its outer end a milled knob, and on its inner end carrying a small wheel or pinion, which actuates a connecting wheel or pinion, the teeth of which take into teeth formed on the edge or periphery of a double wheel, which is formed with a recess on one surface, around the edge of which are formed rachet teeth, which, when such recessed wheel is made to revolve in one direction, will slide on, and when moved in the other direction will, whilst winding the watch, gear with the teeth of the ratchet wheel on the axis of the winding mechanism, which rachet wheel revolves within the recess in this double wheel, whereby a direct and simple means of effecting the winding is obtained. The teeth of the re-cessed ratchet wheel are kept in [illegible] during winding with the teeth of the [illegible] wheel on the winding axis by a spring [illegible] on one end of a bar, which carries the [illegible] wheel with capability of freely revolv[illegible] bearings carried by such bar, this bar [illegible] on a fixed centre at the opposite end. [illegible] the setting this bar is moved by a pin or [illegible] projecting through the rim of the watch so as to bring the teeth on the periphery of the double wheel into gear with a wheel affixed to the shaft carrying the hands, and at the same time the teeth of the ratchet wheel will clear the inside ratchet teeth of the double wheel, such ratchet wheel being of slightly smaller diameter. The spring acting on the bar causes the wheel to be replaced on pressure being removed from the stud or pin when the desired setting has been effected.

But that the invention may be better understood I will, by the aid of the accompanying drawing, proceed to describe means pursued in carrying the same into effect.

Figs. 1 and 2 show two internal views of so much of a watch, with the improvements applied thereto, as will serve to illustrate the invention.

Figs. 3, 4, and 5 show separately various parts, or parts in different positions, in order that their construction may be better understood.

In each of the figures the same letters are aployed to indicate corresponding parts.
The dotted lines *a a* indicate the outline of e watch frame; *b* is the pendant, and *c* the iob of a spindle *d*, which is passed through e stem of the pendant, and has a small nion *e* applied to the inner end of it, as in e case of other arrangements of what are called keyless watches. The teeth of this pinion *e* take into the teeth of a wheel *f*, which is supported to turn on the bearing g^1, which bearing also serves as a support and fulcrum for the bar *g*, and this bar *g* carries, with capability of its free rotation thereon, the tooth wheel *h*, the teeth (1) of which are taken into by the teeth of the pinion *f*, so

Fig. 1.

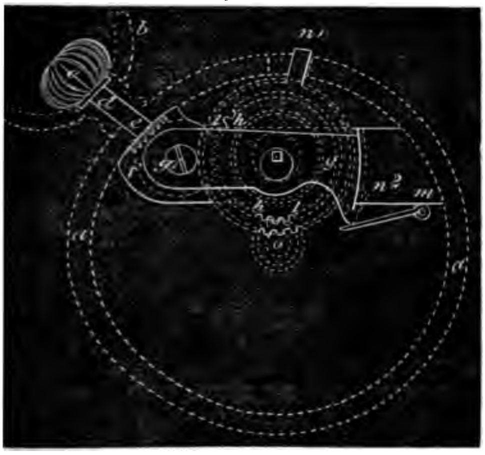


Fig. 2.

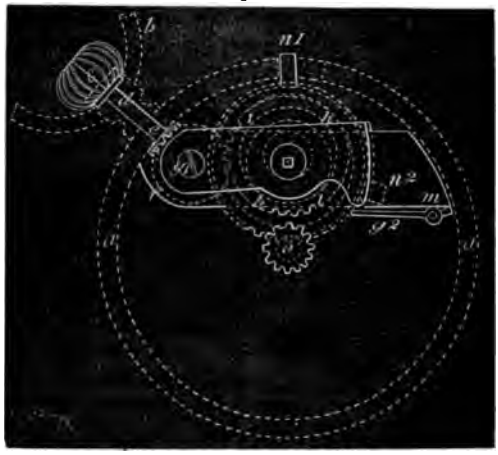


Fig. 3.

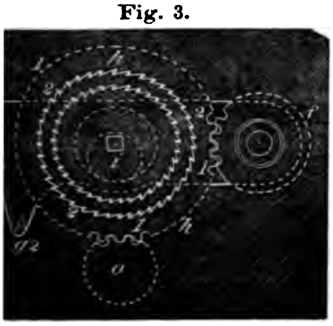


Fig. 4.

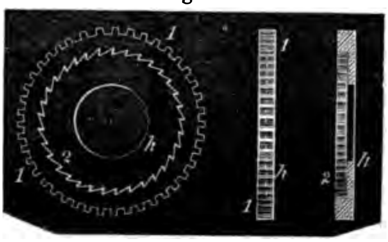


Fig. 5.

at the pinion *f* serves as an intermediate heel between the pinion *e* and the wheel *h*. ie surface of the wheel *h* is recessed, and is formed thereon the ratchet teeth (2), hich, when the bar *g* is in the position dicated by Figs. 1 and 4, take into corsponding ratchet teeth formed on a wheel *i* fixed to the axis, to which one end of the ain spring is attached in the spring barrel *k*. ie bar *g* is formed with a projection g^2, hich is acted upon by a spring *l*, with a ndency to keep that bar in the position dicated by Fig. 1, with the projection g^2 (as rne by the spring *l*) resting against the acket *m*. When the parts are in the sition thus described, and as represented by g. 1, by turning the knob *c* in one direction e teeth (2) of the wheel *h* will act on the eth of the wheel *i* to cause that wheel to volve and wind up the spring in the irrel *k*. When the knob *c* is turned in the opposite direction the spring *l* will yield and admit of the wheel *h* turning without any effect to the parts. One-half only of the thickness of the wheel *i* lies within the wheel *h*, and the other part of the thickness thereof projects so that a spring catch k^1 takes into the teeth thereof to prevent unwinding; *n* is a hoop, with two projections n^1 n^2, by turning which, by acting on the projection n^1 to move it in the direction of the arrow, the projection n^2 will act on the projection g^2 of the bar *g* to overcome the pressure of the spring *l*, and remove the teeth (2) of the wheel *h* from contact with those of the wheel *i*, and bring the teeth (1) of the wheel *h* in gear with the teeth of a pinion *o* on the axis of the minute hand, as indicated by Figs. 2 and 3, by which the hands may be set in either direction, as desired, and then when pressure is removed from the projection n^1 of the hoop *n* the parts will return to their former position.

THE DIAMOND AND OTHER PRECIOUS STONES.

By M. BABINET, of the Institute of France.

(From the "Smithsonian Report" for 1870.)

(Continued from Page 110.)

Now, if we recollect that before diamond-cutting was understood the opal was the only stone which, receiving the white light of day, gave it back refracted in a thousand magic tints, this price does not appear too much for a gem which was the *Koh-i-noor* or the *Regent* of Rome. The opal, at the same time that it is the lightest of all gems, losing in water one-half its weight, is also one of the softest. Those of India are somewhat superior in these respects.

In actual value the Paris market places, next after the opal, two stones of an undecided greenish yellow, viz., the *chrysolite* and the *peridot*. The first is characterised by its lively lustre, its polish, analogous to that of the sapphire, and its warm bright tints. It is the "stone of affection" of Sir David Brewster, so celebrated for his researches in optics. The chrysolite, or *Cymophane*, has often the milkiness of the sapphire. To enumerate its other properties we must enter the broad field of modern optics, speak of double refraction, of polarisation, and the colors which are exhibited in the light which traverses crystals, and, finally, of the three kinds of colored rings, namely, those with black lines, those with black crosses, and those without either lines or crosses. The rings in the chrysolite, as in the topaz, are of the first kind. This is not, however, a distinguishing property, since it can be made to appear, with a little dexterity, in almost all cut stones. As to the *peridot*, or *olivine*, its color is deeper than that of the chrysolite; it is always of a greenish olive, mingled with yellow, the green predominating, is very soft, scarcely scratches glass. Its lack of hardness gives an appearance of dullness to its edges. The *peridot*, which comes to us from India, is there used as ornaments of harness, as well as are the flatly cut emeralds of the same country. Ceylon, which is above all other places, distinguished for the production of colored stones, does not continue to furnish the peridot, which, however, is not rare in the lava from volcanoes, although the specimens are too minute to be worthy of the art of the lapidary.

I have often seen in the possession of an amateur interesting collections of these small crystals, which, viewed by lamplight and under a microscope, verified all the crystallographic laws of Haüy. A crystal of a peculiar property, though of the minutest dimensions, was to this eccentric amateur what the *Star of the South* would be to an ordinary collector of diamonds. His long and minute investigations gave him great facility in the study of minute gems. From a stone covered with small crystals he would select one, which, under the microscope, and properly lighted, would present the most interesting scientific indications.

The *peridot* has the distinguished honor to be the only precious stone that has thus far been found in aerolites falling from the sky, although these little olive stones are of no great value if sold by the carat; but if suitably cut in their matrix, they afford, if not very beautiful, certainly very curious, specimens. I need scarcely say that the existence of a crystallised stone found in bodies falling from the atmosphere refutes the idea that these meteorites are formed suddenly by the condensation of exhalations from the earth. The regular disposition of the particles of a substance in the form of a crystal requires immense time, as well as perfect freedom of motion.

From the *peridot* we pass to the *garnet*, which is a ferruginous stone of a deep red color, and often wanting in transparence. It is, however, sometimes found of the beautiful color called peach-bloom. To the perfection of colors it is necessary that a specimen should join a regularity of tint, wanting which constitutes a defect easily perceived by an eye properly trained. There is sometimes found with cut garnets a very pretty assemblage of stones in juxtaposition, which gives a very agreeable appearance of black mingled with red. The only garnet I have ever seen of any value is the *hyacinthe*, a stone of a luscious orangy yellow color, having a little the appearance of candy made of brown sugar. This stone, which Haüy wrongly separates from garnets, is not much esteemed, except by amateurs or collectors of curious specimens. The Hollanders formerly cut garnets into a pearl shape, which were strung in necklaces and used as money among the slave-traders. As in sapphires, *astérs* may be observed in

garnets, and I have been able to verify, by the cutting, all that this phenomenon indicated of the structure of the stone.

In the garnet can be developed crosses with six, and also with four limbs, besides straight and oblique crosses, without counting certain circles of light resulting from a cutting perpendicular to the *astérial* filaments.

Both for mineralogy and also for optics the study of gems affords many important facts. It is to the study of mineralogical optics that Malus, Arago, Fresnel, and Biot, in France; Huyghens, in Holland; Wollaston and Sir David Brewster, in England; and Seebeck and Haidenger, in Germany, owe so much of their renown, and to which the science of light is indebted for its most beautiful discoveries.

Pliny gives no Latin name to the garnet, but confounded it with all stones of a red color, under the head *carbunculi*. It is the heaviest of gems, and, like the diamond, does not possess double refraction. From the white garnet of Norway very excellent microscopic lenses have been made, although it is ordinarily from the diamond that small and exceedingly powerful lenses of this kind are formed. The cutting of such lenses is very difficult, and the price commensurate with the labour and skill required in the operation. I may here observe that another mineralogical crystal having single refraction, the *amphigène*, strongly refractive and perfectly colorless, may also perhaps be used to form small, powerful lenses.

The *topaz*, whose name is derived from its yellow color, is a mineral which also crystallises in prisms, and is susceptible of being very nearly broken transversely. They are of all colors, and come principally from Brazil and Saxony, though Siberia also furnishes them. The price of the yellow variety, which, strictly speaking, only ought to bear the name of *topaz*, has wonderfully declined during the last quarter of a century. The Brazilian topaz cannot be confounded with the Oriental, which is a beautiful corindon of a yellow color, deepening almost to orange.

Although the topaz is not considered a very brittle mineral, it is said that the Emperor Maximinus, who broke the teeth of his horse with a blow of his fist, and the leg of a beast by one of his royal kicks, was so strong in the hands that he could crush topazes as we crush a lump of sugar. The topaz has been for a long time a great favorite, especially with the Spaniards, but with the caprice of fashion it has of late years greatly declined in the estimation of the public.

It was on the white topaz of Brazil that Fresnel made the important discoveries of double refraction with two axes. It is also the topaz, which bears the name of water-drop, which is made so often to pass for the diamond. In mineralogy this stone serves as one of the types of comparative hardness. Thus, we say a stone scratches glass, scratches rock-crystal, scratches topaz and sapphire, according to the various degrees of hardness. For example, the Brazilian topaz cannot scratch sapphire, which is one test of a diamond. The black diamond of Borneo scratches every stone, even diamond itself. As to the *peridot* and *opal*, they scratch nothing, not even ordinary bottle-glass, which I use in experiments of this kind; as to window-glass, it has become too soft of late to be used as a test, since for economy it is now made with too large a proportion of alkali.

The blue topaz of Brazil has never as deep a tint as that of the sapphire; it is only an aqua-marine of superior quality. Of all topazes the only one highly esteemed is that artificially colored, of a pale rose hue, by means of fire. For the specimens that we wish to experiment with we must choose those of a deep yellow or rich orange color. Afterward they are placed in ashes or sand and submitted to a red, or even a white heat, more or less prolonged. When they are taken out we find the tint changed to the light red of what is called *ruby balais* or *ruby brulée*, (burnt ruby). The gay color of this ruby is very pleasing to the eye. A *dilettante* once remarked to me, "This stone has an amiable character." I was entirely of his opinion as to the moral of this gem, although there is certainly nothing very *sincere* in the means by which it acquires its beautiful tint. If, like the olivixe, the topaz had been enveloped in volcanic fires, it would naturally have become a *ruby balais*, and no cloud would have rested on the truthfulness of its character.

The mineral species which the topaz forms is characterized by a certain quantity of fluoric acid, which it contains exclusively of all other gems. This stone, moderately heated, becomes electric, and will attract light, movable bodies. A delicate linen thread, suspended vertically from one end, is attracted by the warmed topaz as it would be by a stick of sealing-wax after being rubbed on cloth. The topaz shares this curious character only with the *tourmaline*. This latter stone, of which we shall say very little as a gem, is highly prized in optics on account of its polarizing qualities, which are utilized in a great variety of apparatus. It is without any brilliant lustre; and though proposed as a stone for mourning ornaments, to compete with jet, jewellers have not yet made up their minds to employ it for this purpose. For a really rich

mourning decoration black diamonds are the gems to be used, as they have been in Portugal in decorating the crown-royal. The earliest specimens of tourmalines came from Ceylon through Holland. The red tourmaline of Siberia, called also *sibérite*, is pretty enough for a ring; it occurs in minute crystals. The amateur of whom I have spoken had in his collection very small *sibérites*, from Corsica, of a crystalline form and exquisite in color; they would have served as gems for the decoration of the Liliputians. There are beautiful green and blue tourmalines, which come from South America, and are called Brazilian emeralds and sapphires. The aqua-marine, the name of which indicates its sea-green hue, is a stone of a mineralogical character similar to that of the emerald, but little in demand at the present time. It is possible that there may be an augmentation in its price, since no new ones are received in market. This stone loses nothing of its appearance in artificial light, and it is sometimes curious to see a magnificent decoration of sapphires wanting in effect at night, while a cheaper one of aqua-marine is not only preserving its splendor, but seeming to gain in brilliance by candle-light. The English regard aqua-marine with the partiality the Spanish had for the topaz.

This stone takes a beautiful polish, and preserves it for a long time. It is less hard than the topaz, and possessss many optical qualities, on which our limits will not permit us to touch.

We come next to the *amethyst*, the name of which signifies a *specific against drunkenness*.

It is a true rock-crystal of a beautiful violet color; it is essentially a day-light stone. Nothing is wanting to this lovely gem but rarity. Pliny employs the word amethystize as synonymous with violetize. Modern *savans* with their lynx-eyes, find a difference between violet rock-crystal and pure amethyst. The latter is characterized by a series of little undulated strata, which is wanting in the violet rock-crystal. There are specimens of colorless quartz which have a structure similar to that of the amethyst. When certain agates consist of very thin layers of a uniform thickness they take the colors of the spectrum, and are called iridescent agates. It is probable that the myrrhine vases, whose value reaches some hundreds of thousands of francs, were cut from iridescent agates. Sir David Brewster has given the exact theory of this iridescence, ignorant that I had already done so before him in the reports of the Institute.

The same philosopher has also demonstrated that the color of sea-shells is also due to their surface being striated by undulating and closely approximated minute lines; for, if we take the impressions of one of these shells in finely prepared wax, we get the colors, as well as the form, of the specimen. Myrrhine vases were sold at 70, 100, and 300 talents. The talent was about 540 francs. We may find among minerals many stones which, being cut, will make excellent gems. There is the euclase, a weak emerald in color, but not so hard as a real emerald. The *amphigéne* is as pretty as the white sapphire. The prehnite is a tolerably good *céladon*. It is somewhat remarkable that researches in mineralogy have led to nothing new in the way of precious stones. This illustrates a remark of Humboldt that mineral nature is the same from one end of the world to the other, which cannot be said of either the vegetable or the animal kingdom.

There is no hope, then, of our finding anything beyond diamonds, rubies, sapphires, topazes, emeralds, and amethysts. The only resource is the laboratory. To obtain new gems man must not count upon nature, but upon his genius.

In terminating the list of precious stones let us say a word about the white pebble or rock-crystal. This is nothing but flinty sand, crystallized and variously colored. Almost all false gems, so called, are made from rock-crystal or quartz. Thus rock-crystals, cut like the diamond, as Rhine diamonds and Alençon diamonds, are called false diamonds. It is only violet quartz which makes the true amethyst. Recently an attempt has been made, with considerable success, to imitate the yellow topaz with rock-crystal of the same color. There is developed in the stone a very rich, velvety, orange color. As to all the reflections, the tints, the degrees of transparence, or of opalescence—in fine, of all the forms which quartz, a veritable Proteus, can assume, a volume would hardly suffice to detail them. Formerly rock-crystal was used for chandeliers and many other articles for which glass is now substituted. The ancients were cognizant of the power balls of rock-crystal possess to concentrate the sun's rays and of setting fire to bodies. Physicians also used them to cauterize certain wounds, in accord with the adage, "After medicine, the knife; after the knife, fire; after fire, nothing." These balls can likewise be employed as microscopes, especially when they are small. Minute nature might have been studied as well by the ancients as in our day had they been so inclined.

I have not mentioned turquoises, of which there are two kinds, both without transparency. One of these is made from the teeth of the mastodon and colored with copper, a

een céladon. It is a kind of fossil ivory. he other is a true mineral of the same eenish blue color, and is a great deal ad-ired; it costs about forty francs the carat. he turquoise is perfectly imitated by porce-in. This stone, without transparency, can arcely be reckoned among gems; it is rather kind of natural enamel. We have also aitted feldspar, which contains an alkaline inciple, and which yields stones having a other-of-pearl lustre, but without colors. owever, when feldspar is of a golden yellow it, covered with little reddish spots, it is t like a gem, but is at the present time very tle known; it is called *aventurine.*

After the consideration of crystallized inerals in nature we should attempt the itation of them in the laboratory. I do not ean such imitation as paste and color pro-ces. I refer to the reproduction as nature ves the gems to us, and propose the making real precious stones, such as has been tempted in the case of the diamond. I have ready said that Ebelman, at Sevres, has ystallized aluminium and silex, thus making true *spinella.* M. Despretz, in the experi-ents by which he has volatilized charcoal id the diamond, has also melted aluminium nd silex. He has obtained from these sub-ances little hollow spheres, lined inside with rystals, like the cavities which are found in aines containing crystals of various kinds. in all the experiments of Despretz the ex-ceedingly intense heat which he produced by electricity only served to dissipate the particles of the diamond without producing any crystal-lization. It is therefore evident that the diamond is not an igneous production. Its origin is probably electric; but what was the epoch of its first production from ordinary carbon, and where did its crystallization begin?

According to M. Boutigny, the carbon of the earth comes from showers of hydrogen, united with carbon, which watered, as it were, the earth when it was too hot to receive ordinary rains. We have not yet seen the bearing of this hypothesis on the crystalliza-tion of the diamond. I have already said that sulphur and carbon, in uniting together, pro-duce a liqnid as limpid as water or pure alcohol. Now, with this it might be well to try the following experiment: Having filled a strong iron bottle with the liquid, and havin covered it with an iron stopper, firmly screwed into the neck, I would place it in an oven at 200 or 300 degrees centigrade of heat. At this temperature the iron of the bottle and the sulphur would possibly react upon each other and enter into combination. Now, the sulphur, uniting with the iron, would leave the carbon free, which might thus slowly arrange itself in the crystalline form. I merely propose this experiment, which might require a long-continued heat of uniform tem-perature, to illustrate the play of chemical affinity. It is possible the effect would be analogous to that which takes place when a porous body is plunged into a saline solution, which absorbs the water and leaves the salt crystallized on its surface. We should inform those who may be tempted to try this experi-ment that the fluid within the bottle would acquire by heat an immense repulsive force, sufficient to break almost any vessel inclosing it, especially one of iron, after the metal has been acted on by sulphur. The old alchemists frequently met with serious accidents in their attempts to transmute mercury by overheating it in closed iron vessels.

We have just said that there is very little chance that nature will furnish us with any new minerals. We must therefore depend on the results of the laboratory, and examine every substance whose hardness, polish, transparence, and crystallization render them suitable for gems. We may afterward dis-cover the method of coloring them, which would not seem a very difficult task, from the fact that the colorin gmatter is always a foreign substance, and that, in many cases, gems have already been artificially colored. Ebelmen, by evaporating ether from silica, has obtained beautiful specimens of paste, exactly resembling opal. Though man may never be able to discover all the processes of nature in the production of objects of curiosity or practical utility, yet he is every day induc-ing her to disclose some of the secrets of her operations, either as she reveals them spon-taneously in the changes of the earth or is forced to repeat them under the coercion of her own agents—heat, light, and electricity.

British Horological Institute.

DIARY OF MEETINGS FOR APRIL, 1874.

DAY.	DATE	TIME.	BUSINESS.
Monday	13	8.0	Technical Class.
Tuesday	14	8.30	Council.
Thursday	16	8.0	Technical Class.
Monday	20	8.0	Ditto.
Thursday	23	8.0	Ditto.
Monday	27	8.0	Ditto.
Thursday	30	8 0	Ditto.

ACCORDING to the census of 1861 there were eight hundred and seventy-seven watch and clock makers in Clerkenwell.

Letters to the Editor.

All letters to be addressed to the Editor, at the Institute, 35, Northampton Square, E.C.

Size of Pins in Gravity Escapement.

Sir,—The only answer I can give to "J. P.," who asks what should be the size of the lifting pins in my gravity escapements, is that I never could find that it matters what the size is, within any reasonable limits likely to be adopted. If they are very thin they will mark—*i.e.*, slightly cut—the faces of the pallets, however hard they may be; and they must obviously not be so thick as to let the corner of either pallet, and not the flat face, rest upon the pins. In fact, the indifference of these double three-legged and four-legged escapements (but not five) to small minutiæ of this kind is one of their numerous advantages. Everything that is really material is noticed in my book and the last appendix of 1868.

I hope to send you a revised and enlarged sixth edition of it soon, as it is now printing; but I have had nothing of consequence to add on this subject, though I have on some others.

As I am writing, I will also answer "S. L.," who wants a cheap kind of transit or meridian instrument for the sun, that the only instruments that satisfy those conditions are a dipleidoscope, or a meridian slit, of which I shall give a better description in the new edition than in the old ones. Of course, a transit instrument is better, but a transit suitable for the sun requires a peculiar eye piece, and it would be better, and much more likely to be exact, to use it for stars, and turn sidereal into mean solar time, instead of turning apparent solar time into mean.

Yours truly,
E. B. DENISON.

To Correspondents.

*** *A communication from Mr. John Fewtrell on "The Lever Escapement" will appear next month.*

MacIvor.—*Please favour the Secretary with your address, and a reply shall be sent by post.*

I would like if, among your numerous correspondents, one will give an answer to the following, viz., the best method of counteracting the effects of salt water when a watch falls overboard and becomes saturated with water—an occurrence that takes place frequently about seaports.—James Allan, Charlestown, U.S

G. V. S., *in the March number of the* Horological Journal, *asks how to harden case springs, so that the work retains its toughness. When the proper quality of steel for the work has been selected the following method will be found to answer his requirements:—Hold the fly spring in a piece of binding wire in the flame of a spirit or other lamp till it assumes a red heat all over, and cool it quickly in oil or tallow; remove, when cool, the spring again into the flame till the oil which sticks to the work ignites, then let it completely burn off outside the flame. If a screw, proceed in a similar way, but cool it again in the oil before it has been entirely burnt dry. Canon pinions are sometimes left so hard that the examiner cannot fit it to the arbor. It may be sufficiently softened by what is technically called flaring. To do this wind the binding wire many times round the pinion and its pipe, so that a goodly quantity of oil will adhere to it, then hold it in the flame till the oil begins to burn, and quickly cool; repeat this several times, and the pinion may be cleaned with the rouge brush and buff to restore the polish.*—W. G. S.

Obituary.

We regretfully record the death of Mr. Robert Haswell, of 49, Spencer-street, Clerkenwell, who was elected a member of the British Horological Institute in 1858, and whose loss will be felt by a very wide circle of friends throughout the trade. He was born in 1815, came to London in 1830, and spent five years in learning the clockmaking (his master still pursues his craft). Preferring watchwork, however, and employing the little leisure an apprentice's hours in those days afforded in acquiring a knowledge of that branch of horology, he gave his attention wholly to it, and relinquished clockwork. He made lever escapement making his special business, and continued to follow that branch until the increasing attention demanded of him by the tool and material business, in which he had embarked, compelled him gradually to relinquish it. This business had been started some years previously by the late Mr. Hewett, chronometer maker, of whom an obituary notice appeared in the *Journal* some few years back. It was, perhaps, during this period of his life that Mr. Haswell was more generally known, the nature of his business bringing him in contact with all classes in the trade. For thirty-five years he had been in this business, he made it a pleasure, and was always at his post. He was chosen a juror in the International Exhibition, 1862, and was on the committee of the Paris Exhibition, 1867, for the Horological Classes. He was in hopes of enjoying a well-earned rest when he was smitten with a painful malady, which terminated fatally, February 26, at the age of fifty-eight.

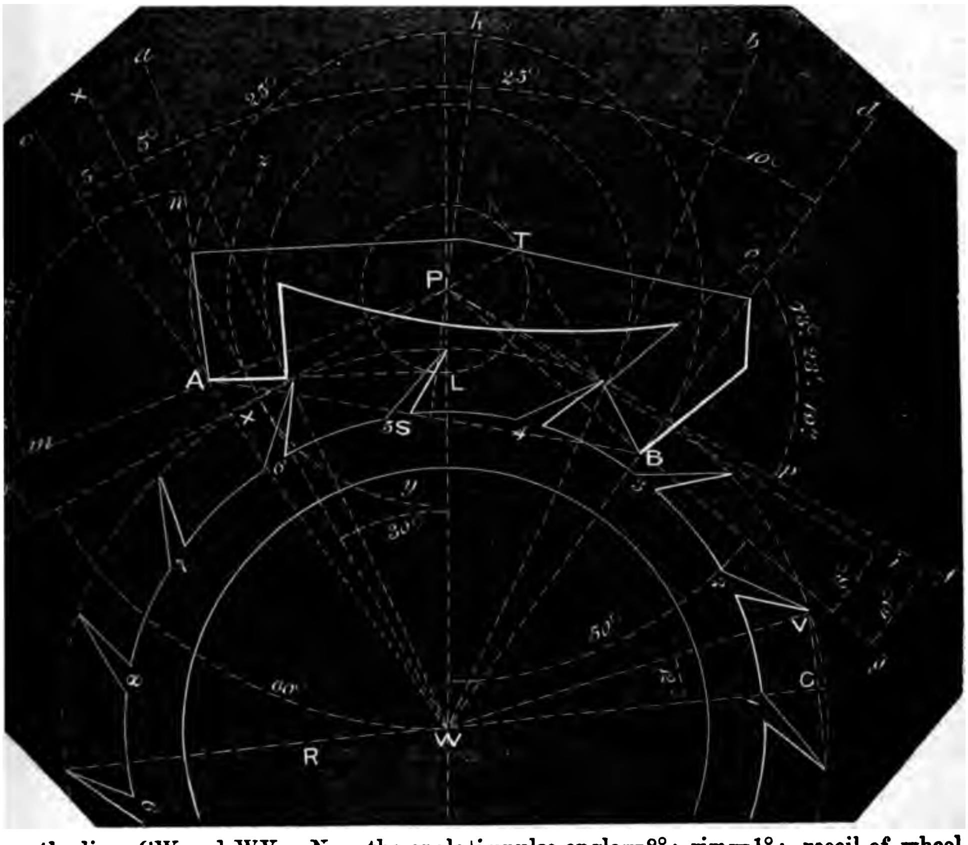
THE LEVER ESCAPEMENT.

GLADLY avail myself of your permission to ntinue my letters, and enclose diagrams and e following calculations for wheel and pallets. I always make the calculations first, as in actice they supersede the drawings, and o enable us to make a more correct draw- ; (on a small scale) when it is required for illustration. Then, again, a drawing, to made even approximately correct, must be a very large scale, and the various dimen- ns reduced by figures to the working sizes; nce, as we cannot avoid calculations, any repugnance that may exist in the minds of my readers to the "drudgery of sums," or the necessary algebraical formulæ, must be over- come, if they really wish to understand the theory of our subject. As I agree with Mr. Reilly that Mr. Grossmann's treatise is an "excellent example of orderly arrangement," I have followed it as far as practicable.

MEASURED DIAMETER OF ESCAPE WHEEL.

Draw a chord of 24° between the points of teeth 1 and 2 (Fig. 1), bisect the chord, and

Fig. 1.



aw the lines CW and WV. Now the angle C is a right angle, and $\surd$ CWV=12°, and V=its cosine=·978; add radius R, and we ve $\frac{1\cdot978}{2}$=·989, as the measured diameter of heel, when real diameter=1. I scarcely ed add the wheel is supposed to be mea- red between the parallel jaws of a sliding uge with the points of teeth 1 and 2 against e, and tooth 9 against the other.

We must now assume the following data, z.:—Radius of wheel=1; angular breadth pallets=10°; drop=2°; locking angle=2°; impulse angle=8°; rim=1°; recoil of wheel during unlocking=30°.; the pallets to 'scape over 3 teeth as usual; hence the angular dis- tance of locking and delivering edges=60° from each other, and 25° and 35° from the line of centres.

DISTANCE OF CENTRES.

Draw a circle round the wheel teeth and the line of centres W P, and also the lines *a b*, *c*, *d*, at 25° and 35° from W P; now draw chords of 10° through the points where *c a*

and *b d* cut the wheel circle, and prolong them both ways till they cross each other, and the line of centres at PP and to *e* and *f* = bisect the chord and draw × W; the length of this from W to the chord is the cosine of 5°, and, of course, it is obtained in the same manner as the line C W direct from the tables of sines, &c., viz:—cosine 5° = ·9961947, and the distance of centres = seconds 30 × cosine 5° = 1·1547005 × ·9961947 = 1·1503 and = $\frac{1\cdot1503}{2}$ = ·57515 = distance of centres, when diameter of wheel = 1.

In the diagram Fig. 1 the radius of wheel = 2; hence the distance of centres W P = 1·15 × 2 = 2·3; and in making a small drawing I lay off this distance on the line of centres, and then draw the lines *e* and *f* from P at an angle of 60°, and they should, of course, pass through the locking and delivering points, as already explained.

RADIUS OF INNER AND OUTER CIRCLES.

The radius × P of mean circle Y Z = Tan 30° × cosine 5° = ·5773503 × ·9961947 = ·5751534 and radius mean circle = ·5751534
× sin 5° = ·0871557

Radius outer circle = ·6623091

Radius mean circle = ·5751534
− sin 5° = ·0871557

Radius of inner circle = ·4879977

If the wheel diameter = 1, take the radius of the inner and outer circles as their diameters, and breadth of pallet arms = sin 5° = ·0871557.

RADIUS OF LIFTING CIRCLE.

From P as centre describe the inner and

Fig. 2.

outer circles, and draw the line *g* 10° from *f* and *i* 8° from *g*. The angular distance of *i* from *f* is the working angle = 2°. Draw the impulse plane of long or hook pallet from *g* on the outer circle to *i* on the inner circle and prolong it to T. Now draw the line *h* 8° from *e*, and the impulse plane of short pallet from *h* on outer circle to *e* on inner circle, and prolong it to L; let fall a perpendicular from P to T, and from P, as centre, with radius P T, describe the circle T L. This is the lifting circle, and to obtain the radius arithmetically we have given two sides of a triangle and the included angle, viz., *a* = radius outer circle, *b* = radius inner circle, < C = 8° (see Fig. 2) required the line ×

$$\text{Tan}\,\frac{A-B}{2} = \frac{a-b}{a \times b}\cot\frac{C}{2}$$

$$\frac{A+B}{2} = 90° - \frac{C}{2}$$

$$B = \frac{A+B}{2} - \frac{A-B}{2}$$

$$\times = a \sin B$$

·6623091 − ·4879977 = ·1743114
·6623091 × ·4879977 = 1·1503068

log ·1743114 = $\bar{1}$·2413258
log 1·1503068 = 0·0608136 −

$\bar{1}$·1805122

log Cotan 4° = 11·1553563 +
log Tan $\frac{A-B}{2}$ = 10·3358685 = 65° 13′ 43″

$\frac{A+B}{2}$ = 90° − 4° = 86 0 0
$\frac{A-B}{2}$ = 65 13 43 −
< B = 20 46 17 −

log ·6623091 = $\bar{1}$·8210607
log sin 20° 46′ 17″ = 9·5497877 +

$\bar{1}$·3708484 log of ·2348813 = radius lifting circle.

HEIGHT OF SEGMENT.

Draw a line, A B, joining the outer corners of pallets, and bisect it in S, and let fall the perpendicular S P and prolong it to K; then S K is the height of segment which we require, and we have given angular distance of pallet corners = 118°, which is bisected by the line S P, hence the angle at P in the right angle P S A = $\frac{118°}{2}$ = 59° and P A = radius outer circle, therefore the line S P = cosine 59° × radius outer circle.

g ·6623091 = $\bar{1}$·8210607
g cosine 59° = 9·7118393 ×

$\bar{1}$·5329000 = log of ·3411143
dius outer circle (P K) = ·6623091
× the line S P = ·3411143

ight of segment = 1·0033234 when a dius of wheel = 1 or $\frac{1 \cdot 0033234}{2}$ = ·5016617 heel diameter wheel = 1.

DRAW ANGLE, FIRST PALLET.

(Fig. 2) We have first to calculate the ngth of line b, and for this purpose the allet is supposed to be "dipped" into the heel 3°, that is 2° locking and 1° run, and he wheel tooth is supposed to have advanced 30′, and will, of course, "recoil" the same 30′ during the unlocking. We have now a triangle, of which we know two sides and the included angle, viz., b = radius wheel = 1, a = distance of centres = 1·1503, and < C = 35° − 30′ = 34° 30′, and require the third side c and the angle B.

$a - b$ = ·1503 = log $\bar{1}$·1769590
$a \times b$ = 2·1503 = log 0·3324991 −

$\log \frac{a-b}{a \times b}$ = 2·8444599

$\frac{C}{2}$ = 17° 15′ = 10·5079269 + log cotan

log Tan $\frac{A-B}{2}$ = 9·3523868 = 12 41 10

$\frac{A+B}{2}$ = 90° − 17° 15′ = 72° 45′ 0″

$\frac{A-B}{2}$ = 12° 41 10

< B = 60 3 50

C = 34 30 = log sin 9·7531280
B = 60 3·50 = log sin 9·9378098 −
$\bar{1}$·8153182 = log of
·653609 = c or b Fig. 2.

Angular distance of b from line of centres = 60° 3′ 50″
Do. do. of pallet corner = 57 0 0 −
< C Fig. 2 = 3 3 50

We have now another triangle, of which we know a = radius outer circle = ·6623091, and b = ·653609, and < C = 3.3.50, and require < B.—

·6623091 − ·653609 = ·0087001 = log 3·9395242
·6623091 × ·653609 = 1·3159181 = log 0·1182229 +

3·8213013

$\frac{2}{C}$ = 1° 31′ 55″ = log cotan 11·5727800 +

$\frac{A-B}{2}$ = 13° 55 = log Tan 9·3940813

$\frac{A+B}{2}$ = 90° − 1° 31′ 55″ =
88 28 5
$\frac{A-B}{2}$ = 13 55 −

74 33 5 = < B = C B F Fig. 2.
31 = < S B C

105 33 5 = S B F = Draw angle.

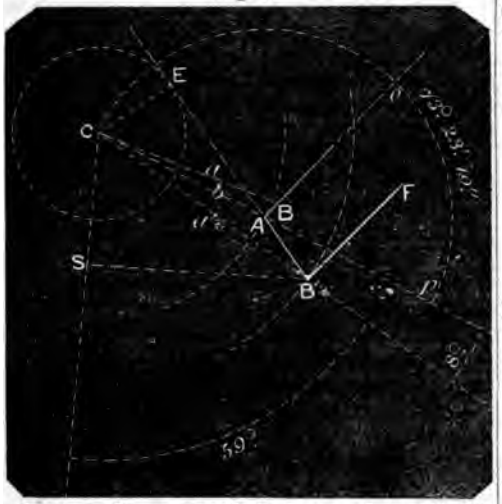
The arc m n Figs. 1 and 2 is the supplement of < B = 180° − 74.33.5 = 105.26.55. I use this arc or its chord in drawing the ocking face, in preference to the angle B, as it is outside the pallets, and thus causes less onfusion. The length of the chord is obtained thus $\frac{105 \cdot 26 \cdot 55}{2}$ = 52° 42′ 25″ natural ne = ·7955527 × 2 = 1·59 = chord of 105.26.55. To draw the locking face from Fig. 1, as centre, and 1 in. as radius, describe arc m n, and lay off the distance 1·59 along the arc from m to n, and draw the face A n and the inner face parallel to it, and this pallet is complete.

DRAW ANGLE, SECOND PALLET.

For this we have first to calculate the length of line a Fig. 3, and the distance of centres and the radius of wheel are again the two sides of the triangle, of which we require

the third side and the angle B, but the included angle is now 25° 30′, the tooth of

Fig. 3.



wheel again supposed to have advanced 30′ and the pallet dip = 3°.

From p. 9 we obtain

$$\log \frac{a-b}{a+b} = 2{\cdot}8444599$$

$$\frac{C}{2} = 12^\circ 45' \text{ log cotan} = 10{\cdot}6453598 \times$$

$$\log \text{Tan} \frac{A-B}{2} = 9{\cdot}4898197 = 17^\circ 9' 57''$$

$$\frac{A+B}{2} = 90 - 12.45 = 77\ 15$$

$$\frac{A-B}{2} = 17\ \ 9\ \ 57$$

$$60\ \ 5\ \ 3 = \angle B$$

$$\log \sin C = 25^\circ 30' = 9{\cdot}6339844$$

$$B = 60^\circ 5' 3'' = \log \sin = 9{\cdot}9378983 -$$

$$\log a \text{ Fig. 3} = \bar{1}{\cdot}6960861 = {\cdot}49669$$

Angular distance of a from line of centres $= 60^\circ\ 5'\ 3''$

Do. do. of b $= 57$ –

$\angle C = 3\ \ 5\ \ 3$

We have now $a = {\cdot}49669$, $b =$ radius inner circle $= {\cdot}4879977$ $\angle C = 3.5.3$, and require $\angle A$.—

$${\cdot}49669 - {\cdot}4879977 = {\cdot}0086923 = \log \bar{3}{\cdot}9391297$$

$${\cdot}49669 + {\cdot}4879977 = {\cdot}9846877 = \log \bar{1}{\cdot}9932985 -$$

$$\frac{a-b}{a+b} = \log\ \ \bar{3}{\cdot}9458312$$

$$\frac{C}{2} = 1^\circ 32' 31'' = \log \text{cotan} = 11{\cdot}5699616 +$$

$$\log \text{Tan} \frac{A-B}{2} = 9{\cdot}5157928 = 18^\circ 9' 29''$$

$$\frac{A+B}{2} = 90 - 1^\circ 32' 31'' = 88^\circ 27' 29''$$

$$\frac{A-B}{2} = 18\ \ 9\ \ 26 +$$

$$\angle A = 106\ \ 36\ \ 55$$

180 0 0
106 36 55 — $\angle A$

73 23 5 = arc $o\,p$.

$\frac{73.23.5}{2} = 36\ 41\ 32 = \sin {\cdot}5975 \times 2 = 1{\cdot}195 =$ Chord of arc $o\,p$.

$\angle CAB = 106^\circ\ 36'\ 55''$
$\angle ACB = 3\ \ 5\ \ 3$
$\angle ACB^2 = 8\ \ 0\ \ 0$
$\angle CB^2A = 20\ \ 46\ \ 17$

$\angle B^2AB = 138\ \ 28\ \ 15$

180 0 0
$\angle B^2AB = 138\ \ 28\ \ 15$ —

$\angle AB^2F = 41\ \ 31\ \ 45$
$\angle CB^2A = 20\ \ 46\ \ 17$
$\angle CB^2S = 31\ \ 0\ \ 0$

$\angle SB^2F = 93\ \ 18\ \ 12$

only now to lay off the chord $o\ p$ at ce 1·195, and draw the locking face the end of impulse plane and the e parallel, and pallet two is com-ne wheel teeth are drawn with just slope for the point only of the tooth on the locking faces; by laying a dge along the locking face of second can easily see if they are sloped In the diagram the front of the portion of the chord of six teeth ack part of chord of 5 teeth, which, seen, is about right.

the diagrams and calculations will correct, according to the given or data, but whether the "data" is ll depend on the size of the watch collateral circumstances into which it present enter. I may, however, at the amount of "draw" necessary calculated, but must be obtained r in the pitching tool or plates.

JOHN FEWTRELL.

ham.

IPROVED MERCURIAL PENDULUM.

in the February number of your t you continue the discussion on nann's improved mercurial pendulum. rst ventured to disagree with Mr. n on this subject I had no idea that sion would excite sufficient interest blished in your columns; but since been pleased to publish it so far, I pectfully ask of you to publish the r. Grossmann's last article which I you along with this letter. This e discussion so far as it appeared in ns of the late American *Horological*

CLYDE.

ORITZ GROSSMANN—Dear Sir—In this ation I prefer to address you directly, e that you will excuse the liberty I ause my reason for so doing is to he recurrence of that unpleasant hich I fear exists in your mind, the supposition, on your part, that d you treated the principles involved improved compensation pendulum sly or superficially. Now, sir, no as studied any of your writings can n of treating any subject super-ut in these few past years this f improving the compensation of pendulums is one which has occupied the attention of many inventive minds in this most inventive country, and, although many patents have been taken out for supposed improvements in this line, I regret to be compelled to state that, with scarcely an exception, the inventors have displayed no more knowledge of the principles involved in the improvement of the compensation of a pendulum than if they had been compensating the handle of the town pump so that it would have the same amount of leverage in winter as in summer. To this class my remarks regarding patent pendulums were addressed; certainly not to you, or to any other individual so deeply skilled in the science of Horology. The only analogy I know that exists between a patent pendulum as it is understood in the United States, and patent medicine as it is understood to be all over the world, is that the one proposes to cure the irregularities of the clock, the other the physical irregularities of man, and they are usually both equally effective.

You have been kind enough to notice my communication regarding the mercurial pendulum and the expansion of mercury, which appeared in the tenth number of the first volume of the JOURNAL. The paradox that you point out as existing in Reid's Treatise may be partly explained by the fact, not generally known, that the greater portion of this book was written originally as the horological article for the new edition of the *Edinburgh Cyclopædia*, and which was afterwards enlarged and published in book form, under the name it now bears. The tables you quote are not to be found in the original article, but only the statement that mercury expands nearly 5.75 times more than the steel rod. I do not know who is responsible for the addition of these tables, which substantially agree with the cubical expansion given to mercury by most of our later authorities, and which appear to be so contradictory to the conclusions Reid himself arrives at. My quotation from Charles Frodsham, regarding the expansion of mercury, was extracted from the second edition of a small work, entitled, "A Few Facts connected with the Elements of Watch and Clockmaking," by Charles Frodsham, 84, Strand, London, and on page 36 of this work it is stated that "mercury, in glass, expands from 5.73 to 5.81 times that of steel rod."

I am not prepared to support either Reid or Frodsham's opinions regarding the expansion of mercury; neither am I willing, at present, to admit that they are substantially wrong, for it does seem to me that mercury is acted upon differently when in a vessel swinging

backward and forward through the air, like the jar of a pendulum, than when it is in vessels usually employed by philosophers in their experiments to determine its cubical expansion. I propose to set this question at rest, and have been engaged contriving some arrangement with a view of practically testing, by giving some visible or audible proof to the senses, whether the steel rod or the mercury in the jar of the ordinary Graham pendulum moves first by a change of temperature, when swinging backward and forward on the clock, and also to show how much they do move for a given change in the thermometer. An experiment of this kind is a delicate one, and consumes a great deal of time, while I, like most mechanics, can only afford to be employed upon it as a recreation in hours of leisure, and it may be some time before I find any result sufficiently well verified to be published. However, as regards the expansion of mercury and steel, my opinion, which is principally based on the experience of every-day life, is that the mercury moves before the steel, in the ordinary Graham pendulum, by any change in the temperature, and especially if the change be sudden. This is also the opinion of other practical men of the present day; and if we go back eighty years it was also the opinion of men prominent in the profession at that period. Troughton's mercurial pendulum is based on the supposition that the mercury in Graham's pendulum is too readily affected by changes of temperature; and the sole aim of Troughton was to keep the mercury as much as possible from the direct influence of the surrounding atmosphere, and it is said clocks with this pendulum perform very well.

I need scarcely remind you of the fact that if we take a number of uniformly well made clocks, with Graham escapements and uncompensated pendulums, with metallic rods of precisely the same length, and each rod composed of precisely the same quality of the same metal, and set them running independent of each other, but all going exactly under similar circumstances, no two of them will keep exactly the same rate; they will neither lose exactly the same in warm weather, nor gain exactly the same in cold; and none of them will gain or lose as much as they ought to do, theoretically, for the amount the pendulum has been lengthened or shortened by the various changes in the temperature. Now, from this does it not seem probable that the variable friction which the Graham escapement presents to the free excursions of an ordinary compensated pendulum, affects in an irregular manner part of the compensation that the mercury gets credit for? Take away the resistance of this escapement to the free vibration of the pendulum, and immediately the necessity for more mercury becomes visible. My suspicions in this matter were first aroused, not by the reading of books, but by the behaviour of several clocks having their pendulums less under the varying influence of the mechanism of the clock than the pendulums of any other clocks in existence, so far as I have been able to learn. I notice that the same phenomenon has been observed in England, only in a less degree, because the pendulums were not so free from the varying influences of the mechanism as the pendulums I had an opportunity of observing.

Whether mercury expands six times or sixteen times more than steel, and if the centre of oscillation be raised up by the expansion of the mercury as much as it has been let down by the expansion of the rod, and *vice versa*, and if the action of both be simultaneous, why is it that a column of mercury eight and a half inches long, and about two inches in diameter, is not sufficient to compensate a *free* pendulum, although the jar, which is of iron, is no heavier than is necessary to secure strength enough to contain the mercury? The opinion that there is a necessity for a longer column of mercury, in order to effect a perfect compensation in a pendulum, is very general. However, I am inclined to think that the more we follow popular ideas, and the longer we make the mercury columns, the more we violate the laws and principles upon which the motion of the simple or ideal pendulum is based; but I will say more on this point as I proceed with these remarks. This is one of the reasons why I despair that we shall ever be able to make any improvement that will be of any practical value upon Graham's pendulum. Various improvements upon Graham's original plan have been suggested and adopted very extensively of late years; but, imperfect as Graham's plan is, looking at it from one point of view, in practice it compares favourably with any that are popularly considered to be superior in some points of their construction. Should this assertion be doubted, I can produce well-authenticated rates of the running of different clocks having movements with Graham's dead-beat escapement, in every respect the same in construction and equal in workmanship, but having mercurial pendulums all different in construction; and the clock, having the pendulum the same as Graham made it, runs as regular as any of the other clocks having mercurial pendulums of a more modern construction. If there be any superiority in the regularity of any of the rates of these clocks it is in favour of the one with the old Graham

ulum; and, although all the clocks run gular as any clocks do, none of them run that absolute regularity that is so much ed for some purposes.

will now proceed to make some further re- s on your own pendulum. You still ad- to the belief that there is a difference of erature amounting to as much as seven ees Fahr. for every three feet, from the to the ceiling, in rooms heated by stoves, customary in Germany, and that this difference is based upon natural laws. ese laws be universal we ought to see evidence of their existence in the United s, because stoves are also used to a very extent in this country, and in smaller s the ceilings of the rooms generally are igh. In addition to what I have already d on this subject in my first notice of your ulum, I may mention that a short time had the curiosity to try the experiment r the most extreme conditions I could selecting a room with a low ceiling and little, if any, ventilation. The room was d by a close stove, and the greatest dif- ce I could find in the temperature was degrees Fahr. in a distance of ten feet. , I am inclined to give considerable weight ny observations made by such a distin- hed person as Mr. Kessels, of Altona. I seen an astronomical clock that bears his , and which is in use in the United States t Survey, and I will say that, for a port- clock, designed for field service, I never one where more sound judgment was dis- ed in every detail of its construction, and not inclined to think Mr. Kessels to be ntleman likely to jump at a conclusion; as one of the readers of the Journal, I d rejoice to see his memoir published in pages.

though you state that the length of your ulum is no mistake, as I supposed it to be, with all due deference to your statement, nnot think that it will beat seconds, out some further explanation; and I base onclusions upon the following calculation. total length of your pendulum is 48.43 s, but for simplicity I will call it 48.5 s, from the point of suspension to the m of the four mercury cylinders. I will draw a line through the centre of the rod, the axis of suspension to a point 39.2 s below this axis, which is about the ce the centre of oscillation of the pen- a should be from the axis of suspension, der to make it beat once in a second; quently, the point at the end of this line have drawn will be 9.3 inches from the t extremity of the pendulum. The four ry cylinders are 17.7 inches high, the half of which is about 8.8 inches. Take 8.8 inches from 9.3 inches, and the point at the lower extremity of the line will be .5 of an inch above the centre of the mercury cylinders. Without taking the weight of the rod into consideration for the present, this point will be very near the centre of gravity of the bob, and not far from its centre of oscillation. There is, however, about 30 inches of the zinc pendulum rod extending above the mercury cylinders, and, as this rod is .69 of an inch in diameter, its weight must be very considerable, and will tend to raise the centre of oscillation of the whole mass which composes the pendulum a considerable distance above the point at the end of the line I drew down through the centre of the rod, and consequently the pendulum will not beat seconds, according to my way of thinking; but I will be pleased to learn if all the figures in your first communication are correct, and if they are the dimensions of a pendulum actually in operation, and which makes exactly one beat in a second.

I think you misapprehend my meaning as regards the inference I drew from the small weight sliding on the pendulum rod, which was much used as a means of regulation in clocks in former years. It is true that this weight will influence the rate in opposite directions, according as it is placed above or below the oscillation, but the rate of the clock will not be influenced in proportion to the distance the weight is moved from the centre of oscillation. In a pendulum where the matter which composes it is distributed in the same proportions as in an ordinary Graham pendulum we will suppose a small weight of a certain size, constructed to slide on the rod, and at a distance 35 inches from the axis of suspension it causes the clock to gain 4 seconds per day. If we slide the weight 5 inches nearer to the axis of suspension the clock will gain nearly 8 seconds per day; 5 inches more and the gain will be nearly 10 seconds per day; 5 inches more, which will bring it to a point about 20 inches from the axis of suspension, and the rate will be only 11 seconds per day gaining; the next inch will produce on difference. At 15 inches from the axis of suspension the rate will be reduced to 10 seconds per day gaining; 5 inches farther up, the clock will gain 8 seconds per day; another 5 inches, and it will gain only 5 seconds per day; and when the weight is one inch from the axis of suspension the clock will gain about one second per day. If we suppose the rod to extend a few inches below the centre of oscillation, and the sliding weight transferred to this rod, the effect of moving the weight will be more visible than it was when it was above the

centre of oscillation. From this statement we get an idea of how many contending forces are operating against each other in the material pendulum, and that these opposing forces increase in proportion as we depart from the ideal pendulum.

In mentioning this subject previously my aim was to show what would be the result if you could carry your mercury columns the whole length of the pendulum, in order that they and the rod should be influenced the same by any change in the surrounding atmosphere. It is plain that, the expansion of the mercury having a different value as it ascends the rod, the object you aim at in constructing your pendulum would thereby be defeated. In your last communication you say: "But suppose the jars of my pendulum to reach from the bottom to the top of the pendulum, will not the centre of oscillation be in the middle of its length then, and will it not remain there if the compensation is correctly calculated?" I would beg leave to suggest that in your pendulum the centre of oscillation cannot remain in the same place by changes of temperature. If the jars extended the whole length of the pendulum the centre of oscillation would be somewhere about the centre of the mercury column and about the neighbourhood of 24 inches from the point of suspension, which would make it too short to beat seconds; consequently, it would be necessary to increase the length of the pendulum to an enormous extent to get it to beat seconds; and all the conflicting forces I have already hinted at would be proportionally increased.

I admit that the shape of a body has an influence upon its passage through a fluid medium, but a cylinder may be supposed to have a surface favourable to an easy passage through the air; and it is only cylindrical-shaped bodies that are supposed to be in the question at present. You have four long small cylinders in your pendulum, and your aim is to have them entirely surrounded by the atmosphere, with the idea of facilitating the expansion or contraction of the mercury with which they are filled. In accordance with Galileo's theory, that bodies of the same shape and density, without regard to their size, meet with the same resistance passing through the air, I still claim that *one* of your four small cylinders meets with as much resistance from the atmosphere as Graham's large cylinder does; and if you suppose the narrow enclosure of a clock case to be different from the open air, you must remember that Graham's pendulum is in the same condition as yours in this respect.

I hope that this discussion will continue and be carried on in language easily comprehended by the readers of the JOURNAL. I would be stating a falsehood, were I to say that I did not wish to get the best of this argument; still, my main object is to be able to see my ideas as others see them, and get at the truth. I am open to conviction, and if you can show us a rate of a clock having one of your pendulums, which is better than the rates of clocks having Graham pendulums, or pendulums of any other construction usually employed on standard clocks, or by any process of reasoning that yours *has* the advantages you claim for it, I should be most happy to acknowledge it.

CLYDE.

THE Americans, who are always congratulating themselves on the possession of big things, are now congratulating themselves on possessing "what is probably the most powerful telescope in existence, or that has ever been constructed." The new instrument, which has just been mounted at the United States Naval Observatory in Washington, at a cost of £8,800, is a refractor with a steel tube 34 feet long, and an object glass 26 inches in diameter. It is described as being so admirably poised that "the pressure of the finger is sufficient to turn it in any direction," and a clockwork, driven by a small water wheel, "causes it to follow the motion of the heavens with perfect precision." It is, of course, admitted that there are half a dozen reflecting telescopes of larger dimensions than the new refractor. That of Lord Rosse, with an aperture of six feet and a length of sixty; that used by the elder Herschel, and that belonging to the Melbourne Observatory are well-known examples. Still, for observatory work, the superiority of the refractor to the reflector is so great that the size of the enormous instruments named is compensated by the power of that recently erected at Washington. Among refractors Mr. Newhall, of Newcastle-on-Tyne, was, we believe, till now the owner of the largest in existence, his instrument having an aperture of twenty-five inches and a length of thirty-three feet. It is a question, therefore, whether the addition of an inch and a foot respectively to the aperture and length of the American refractor was not made solely with a view to its becoming "what is probably the most powerful telescope in existence, or that has ever been constructed." If this is so, however, Mr. Newhall will soon be avenged, for the same paper which describes the new instrument announces that the firm which constructed it is engaged on another, "in all respects similar."—*The Globe.*

THE HIGHER HOROLOGICAL ART.*

FOR THE CONSTRUCTION OF ASTRONOMICAL, NAUTICAL, AND OTHER EXACT TIME MEASURERS.

(By URBAN JURGENSEN.)

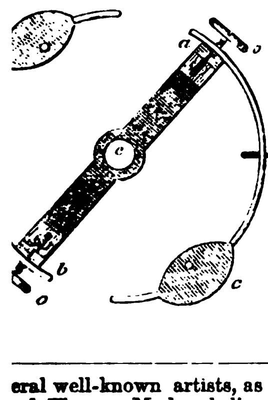
(Continued from Page 121.)

SECTION III.

[SATION BY MEANS OF THE BALANCE. RESISTANCE OF THE AIR TO A COMPEN-]N BALANCE. THE ISOCHRONISM OF THE [...]LATIONS OF THE BALANCE.

[...]st complete compensation is that which [...]ined by means of the balance itself, [...]rough this alone can we hope for an [...]and regular performance in changing [...]atures.* The principle of the compen-[...]y means of the balance is both simple [...]genious, for heat, which would make [...]illations of the balance slower, dimi-[...] at the same time the diameter of the [...]sation balance; but as smaller balances [...]nore quickly; in this way a complete [...]sation is brought about. Cold, on the [...]hand, would make the oscillations [...] but as at the same time it increases [...]ameter of the balance, it causes its [...]ions to be slower, so that here also an [...]ompensation may be obtained. Fig. 20 [...]the compensation balance; *e a* and *e b* the arms of the balance, which carry the bows *a c* and *b d*, which are concentric with the axis of the balance, and near their ends carry the weights *c* and *d*. The bows *a c* and *b d* are each formed of two metals, having different expansibilities, of which the inner metal, or the one nearer the axis, expands and contracts less in heat and cold than the outer metal. From what has been said before (p. 114) of the composite metal rod it will be easily understood that the effect of heat will be to bring the compensating weights *c* and *d* nearer to the centre of the balance, whilst cold will have the opposite effect; and by these movements we can compensate for the action of changes of temperature.

Fig. 20.



The compensation will be stronger or weaker, according as the compensating weights are nearer to, or farther from, the end of the composite bows, and according as they are more or less heavy. The further the weights *c* and *d* are moved towards the end of the bows the larger will be their motion in changes of temperature, and as they approach towards the centre of the balance or recede from it the balance in effect becomes smaller or larger. Heavy weights also bring about a greater compensation than light ones. We thus see that we are in a position to make the compensation stronger or weaker, as it may be required, and if we found, for instance, that the compensation was too strong, we should have nothing more to do than to draw the weights *c* and *d* back towards *a* and *b*; if, on the other hand, the compensation were too weak, we could overcome this evil by pushing *c* and *d* further from *a* and *b*; but if this were not sufficient, we should have to make the compensation weights heavier. The screws *o o* at *a* and *b*, which are in the direction of the arms of the balance, serve for regulating the times of its oscillations; if these are screwed in towards the centre of the balance, the oscillations become quicker; if they are screwed out from the centre, the oscillations become slower. Fig. 21 shows the cock which holds the regulating screw. Fig. 22 shows both cock and screw.

[...]eral well-known artists, as Ferdinand Ber-[...]nd Thomas Mudge, believed it possible to [...] the compensation of the balance spring, [...]first of these artists eventually abandoned [...]thod, and applied himself to the compen-[...]y means of the balance itself, by which he [...] great exactness.

* *Translated from the German, by Mr. George Mayer.*

Only by repeated experiments, and sometimes long and wearisome trials, can we achieve a perfect compensation. It is sufficient here to explain the action of the compensation. In a future number we shall return to this most important subject, and will then explain in greater detail the methods of adjusting.

Fig. 21.

Fig. 22.

Fig. 23.

Compensation balances demand the greatest care in their construction. The different parts which are opposite to each other must be of exactly the same thickness and weight, and the composite segments must be throughout concentric with the axis of the balance; they must also be of exactly the same length, and the compensation weights must be placed on them in such a position that the portion of the circle from the middle of one weight to the middle of the other is just half the circumference of the balance, or, what is the same thing, the two weights must lie in exactly the same diametrical line. Without regard to these rules it is impossible for the balance to retain its equipoise in different temperatures, for, as may be supposed, if the balance is poised in a mean temperature the unequal motions of the segments in a higher or lower degree of heat will bring one of the compensation weights nearer to the centre of the balance than the other, and the balance would thus be no longer in equipoise, which would have the most pernicious effect upon the going of the timepiece, particularly if it were carried first, and afterwards used in a horizontal position. The weights *c* and *d* are, as we have stated, carried by the compensating segments, which go in grooves in the weights, as seen in Fig. 23. These grooves must be of such a breadth that, whilst there is no looseness, the weights must still slide upon the balance without requiring considerable force to move them. Fig. 23 also shows the screw by which the weight is fixed in the desired place.

With regard to the choice of the metals of which the compensation balance is formed, it is, as we have remarked, right to employ two possessing the most opposite degrees of expansion, so as to get a sufficient motion of the segments of the balance. Steel and brass are generally used, and if the steel is hardened the balance is more solid and better retains its form, and there is, besides, not so much danger of bending it. Some watchmakers have formed the compensating rim of platinum and brass, but this method, though very good, has not been generally adopted. It is, above all, necessary that the two metals of which the rim is formed should before being joined be perfectly clean in every part; for if there were not the most complete adhesion between them irregularities in their motion would result, and, consequently, also in the going of the watch or chronometer. The method of melting the brass upon the steel is the one pracised in England, and this method is good. We can also attach the brass to the steel by soldering with silver, and this method is at least as good as the first, if we are careful that the silver solder, which is between the brass and steel, is of equal thickness in every part of the rim of the balance.*

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* A very celebrated English watchmaker has stated that the method of soldering the parts of the balance together is a bad one, and the reason he gives for that assertion is that the metal which is used for soldering the two plates together forms itself a third plate, the action of which, in heat or cold, is quicker than that of the two others. (This does not seem very clear, but he probably means by QUICKER ACTION a greater expansion or contraction in heat or cold.) He considers that this quicker action interferes with the movement of the rim, but it only requires a little thought to perceive the inexactness of this idea, for, as the plate of solder which is between the other two has a greater degree of expansion than the steel, and less than the brass, this cannot in the least interfere with the motion of the segments of the rim, a thing which could only occur if the solder had a greater or less degree of expansion than that of both the other metals together. It is, on the contrary, to be desired that between the two metals which have the greatest difference of expansion we could find a third, the degree of expansion of which should be exactly the mean of the other two. If an authority for this is required I need only cite Breguet's thermometer, an instrument which is more sensitive than any other thermometer, the spiral band of which is formed of three metals, the two outer being platinum and silver, and the middle one gold, the expansibility of which lies between that of platinum and that of silver. As this instrument, constructed in such a manner instantly marks the least change of temperature, we may conclude that the objection that has been raised need not trouble us much. From my own experience I know very well that a soldered balance is just as good, if not better, than a cast balance, and has all the desired sensitiveness and regularity of action. My portable metal thermometers had already shown that the method of soldering the compensation bar was a successful one. I have made several hundreds of these instruments, all of which have silver-soldered bows of hardened steel and brass; their sensitiveness is as great as could be wished, and it cannot be doubted that their motion is regular, as the hand in these instruments moves through a considerable space, although the movement of the compound bow is very small, and so the slightest irregularity in its action, if any, would be shown; but the hand always moves with the greatest regularity.

ON BELLS, AND MODERN IMPROVEMENTS FOR CHIMING AND CARILLONS.

[A Paper read before the Members of the Society of Arts. *]

By GEORGE LUND, Esq.

(*Continued from Page* 120.)

HE foundation of the principle is that iree bells should go through the three ell changes as detailed in chapter two, hile the other bells dodge behind at the ompletion of each six changes, one bell oming down from behind to take its part in ie dodging. But it is not possible to ring it y this plan; therefore it is necessary to give ertain further instructions, and before I do o I wish to call the learner's attention to the act that the treble is no longer the easiest bell to ring, but does exactly the same work as the other bells; this forms one of the great difficulties of the method." Then come the rules for Stedman's principle. The work of each bell is described as divided into three parts, viz., the quick work, the dodging, and the slow work, each being minutely described. He then goes on to say: "In short, and for the sake of making it easy for learning by heart, in coming from behind make 3rd's place, lead a whole pull, strike one blow in 2nd's place, lead another whole pull, make 3rd's place, lead one blow, make 3rd's again, lead a whole pull, one blow in 2nd's, and another whole pull, make 3rd's, and up, or out." After describing more dodging in and out, half turns and whole turns, odd, even, slow, and quick sixes, he says: "I have now, I hope, explained the following terms, and shall use them hereafter without further explanation:—

Quick work.	**First and last whole turns.**
Slow work.	**First and last half turns.**
The dodging.	Going in quick.
Odd sixes.	Going out quick.
Even sixes.	Going in slow.
Slow sixes.	Going out slow.
Quick sixes.	

It is necessary that these terms should be thoroughly understood before the learner attempts to go further. I do not think any of us do thoroughly understand—I can answer for myself—and we will therefore take such sound advice and dismiss the subject, and pass on to another use to which church bells have been put, viz., for the playing of tunes upon them by machinery. These machines have been most aptly described as "rather rough, the barrel end has a rope coiled round it, and it drives two or three wheels, ending in a fly, to regulate the velocity," this meagre description exactly conveying the impression of their meagre effects. There are many of them spread all over the country in various stages of decay. I will only mention three, which have come under my own immediate notice. The first was, until the restorations were commenced, in full force on eight bells at St. Alban's Abbey. One tune after another had gone to rest, till at last "The Curly-headed Plough-boy" alone remained to tell his tale of past glories. He at last has been put in a corner, where some friends of mine, who live close to the abbey, fervently hope he will remain for all time. At Southwell, where there is a minster second only to Lincoln Cathedral in interest as a specimen of early Norman architecture, there are chimes. Here the only remaining tune is, "God save the Queen." The last I came across accidentally at Kettering. There I could make nothing of the tune at all, and ceased to be surprised at it when told by an old inhabitant that I was no exception to the rule. He was the only person who knew that it was made up of the "Old Hundredth" and "Caller Herring," that they were the two last surviving tunes twenty odd years ago, that they had not been played for about that time till two years since, when the machinery was put in order, and he supposed that in the interval they had got so inextricably mixed up together that separated they could not be. He thought it would have been better to have left them alone. We did not disagree upon the point. No doubt there are many machines constructed upon the old principle, which continue to play the music as well as ever they did, proper care and attention having been always bestowed upon them; but bad is the best. If any one should wish to hear a melancholy exhibition of what such machines of comparatively modern construction can do, let him go and hear the Royal Exchange chimes play at nine a.m. and six p.m. Can nothing be done to remove the reproach that the wealthiest city in the world, at its Royal Exchange, presents such a contemptible specimen of discord?

We now come to the more immediate subject of this paper, hemispherical bells, and

modern improvements in the machinery for carillons and chimes, and I would wish it to be distinctly understood, that I do not for one moment desire to be understood to say that this shape of bell will supersede to any great extent the church bell shape, or that the power of the tone of one is to be compared to the power of tone of the other. In the hemispherical shape, a 4½ cwt. bell will produce the same note as 25 cwt. in the church bell shape, and it is quite obvious that 4½ cwt. cannot produce the same volume of sound as 25 cwt. Moreover, these bells cannot be swung. But what I do say is, and my firm have proved it in practice, that hemispherical bells can be used most advantageously in places and spaces of peals of eight and more, with all the machinery necessary to produce the required effects of change ringing, quarter striking, and tune playing, where the other shape could not have been used, first, for want of space, and, secondly, in many instances a most serious consideration, on account of the cost.

That they and our machinery will prove useful in providing for a want which has been greatly felt of late years, viz., the supply of bells and filling the place of ringers in neighbourhoods where they are not to be found, I have no doubt whatever; and I am also of opinion that a very large field for their use exists in towers and turrets attached to country mansions. Their sweetness of tone is eminently suited for this purpose, as all the charming effects of bell music may be obtained from them without the tinkling sheep bell sound of light peals, or the impossible expense and overpowering sound of short distances of peals of the ordinary shape, sufficiently heavy and deep in tone to give good effects.

It is not proposed to enter in this paper into the question whether or not hemispherical bells are constructed on scientific principles. I cannot really tell you upon what principle they are constructed. I have never put the question to the founders of them, for the (to me) satisfactory reason that I do not believe they would tell me if I did. At present I have quite enough to do to make use of them when made. All I propose to do is to give some information respecting accomplished facts with regard to them and the chiming machinery which we have made and are making, under the patent of Mr. Imhof, taken out on the 29th September, 1866—information which we have ventured to think may prove to be interesting to our fellow-members in this society. From time to time we have applied them in isolated cases to clocks with invariable success, but it was not till 1870 that we had an opportunity of ordering a peal of 16 for a tower at Colonel Tomline's, Orwell-park, a few miles from Ipswich. Messrs. Mears and Stainbank, who have given great attention to the founding of hemispherical bells, cast them for us with the most perfect success. The smallest in the peal is 1ft. 4in. in diameter, and weight 3qrs. 13lbs., from which they run down to the lowest in the peal, 3ft. ⅛in. in diameter, which weighs 6cwt. 19lbs. The hour bell is 3ft. 6½in. in diameter, and weighs 9cwt. 2qrs. 5lbs. The peal is in the key of E flat, with two half notes, the key which we consider best adapted for bell music, and was the first of that number and size ever cast. The whole weight is about two and a-half tons, and the bells are arranged in two tiers of wooden bell-frame, the cranks leading to the machinery being placed in the centre of the two, and leading right and left. The whole is contained in a space 7ft. 9in. by about 11ft. high, tier above tier, each bell in its own compartment, so as not to interfere with, or stifle the sound of, its next door neighbour. When the bells arrived at the foot of the tower, it was unanimously considered by the builders' employès engaged on the estate that the tower would not hold them, but, to the intense astonishment of every one, the bell-frame and the bells were all fixed in their places in less than a week, with two feet out of the nine unoccupied. Our first object in undertaking work of this kind is to see the place the bells are to go in, and then to obtain from the architect of the building tracings of the bell-chamber. We then design and carefully draw to scale the bell-frame and bells, knowing approximately their dimensions, so that they are as good as placed, for all practical purposes of construction, in the tower before they are actually cast, and we are then able to state with the greatest accuracy what sized bells can be used. The facility with which these bells can be fixed in their places is one of their numerous recommendations. A hole is drilled through the crown 1⅛ of an inch diameter, and through this and the cross-beam of the bell-frame which is to carry it is passed a bolt, secured by a nut and washers, and in this way each is fastened to its own beam, upon which are fixed the hammers and counter springs to prevent chattering in the blow, so that falling, as it does, from the centre of the bell, the full force of the blow of the hammer falls upon the bell. The machine which we manufactured and applied to these bells chimes the Cambridge quarters the same as the Westminster clock, and plays one of seven tunes twice over or not at will, each third hour with one weight and one train of wheels, but does not strike the hours. A clock being already

was thought desirable to alter that
purpose. It may be here observed
re making, by gracious command of
sty the Queen, a machine for St.
Victoria Park, which does all three
weight and one train of wheels, a
n of which I shall give later on.
nt under which these machines are
ured is the sole invention of Mr.
nd consists in the discharge of the
upon the bell by means of a pin in
barrel, and the provision of a cam
again raise it to the catch from
was discharged; thus doing away
difficulty which is experienced in
ng the wear of the pin in the barrel,
end of the lever in the old principle,
e hammer is raised by the pin in the
cting upon the end of the lever to
e hammer is attached, and so lifting
llowing it to again fall upon the bell,
e the blow; thus from the very first
ects from wear arise—the pin and
th wear, and the time of the music
ght of the hammer are consequently
Mr. Imhof's plan is now universally
edged to be the only one suitable for
pose of chiming machines, and has
plied by Messrs. Gillett and Bland, of
(the only persons besides my own
o have a right to use it), to several
achines, notably at Worcester, Roch-
nd Bradford. No doubt many im-
ents have been made since Mr. Imhof
l the first machine, and I am sure he
adily admits it, but at the same time
t should not be lost sight of that to
ne is due the credit of inventing the
ng of the discharge of the hammer from
ing pin, and it is this which constitutes
nspring of all the improvements which
een from time to time introduced
Gillett and Bland (like my own firm)
advantageous, I believe, to apply Mr.
s system in combination with additions
difications planned especially by them-
I shall abstain from attempting the
ion of their methods, in the hope that
y, at some future time, hear this much
done in a paper by one of themselves,
would not fail to be an interesting and
le contribution towards the elucidation
subject.

LY in the present century there was in
wn of Tetbury, Gloucestershire, a very
t market-house, in front of which was
with a very curious and elaborately
oaken dial-plate, with this motto:—
stant æterna Caducis."

Letters to the Editor.

All letters to be addressed to the Editor, at the Institute, 35, Northampton Square, E.C.

MR. DENISON'S SPEECH AT THE MANSION HOUSE.

To the Editor of the Horological Journal.

Sir,—The address delivered by E. B. Denison, Esq., LL.D., Q.C., President of your Institute, on the occasion of the distribution of the prizes awarded by the judges of the late horological exhibition in London, came upon the readers of the *Journal* in this and other American cities like a sudden thunderclap. The sentiments expressed throughout the entire speech, so thoroughly at variance from what we would expect from the President of a horological society upon such an occasion, surprised, and even shocked, many. The speaker, while arguing for the necessity of more brain work, entirely ignores that kind of labour which requires the use of the hands in addition to that of the brain, and, instead of giving his moral support to the development of those nice manipulations which are so essential in watchwork, when the ability to execute them is so scarce, he ruthlessly tramples obscure and patient merit in the dust and styles the making of chronometer escapements mere fingerwork.

In the course of his remarks your President asks, "Will any man in this room venture to say that a watch will go the smallest degree better or worse, whether its pinions are faced or not, or whether the wheel faces are polished or the screw heads left grey?" Perhaps this invitation does not apply to me; but, as I am a constant and an appreciative reader of your *Journal*, I claim the privilege of criticising what I see in your columns, and would now briefly refer to a few of the points advanced by your President on the occasion I have reference to.

There is no person who will deny that if the acting parts of a watch be made as they ought to be made, that the watch for a time will go just as well whether the other parts be polished or not. However, there is another view to be taken of this question. A watch that is polished in all its parts is less liable to collect dirt, and easier cleaned, than one that is not polished. Polished steel is not so liable to rust as steel that is not polished, and hard steel will not rust so readily as soft steel. At the present time it is needless to examine into the reasons for this. The most superficial observer must have noticed that such is the fact, and therefore I admit it as a fact which

cannot be contradicted, and base my arguments upon it.

A quantity of dirt or dust that would have no perceptible influence on a tower clock would be injurious in a small regulator. An amount that would not affect a regulator would be fatal on some parts of a marine chronometer, and impurities that would perhaps not have a perceptible effect upon a marine chronometer would exercise a most injurious influence on a pocket chronometer, or on a watch. Therefore, in proportion to the power or delicacy of the instrument the necessity for favourable conditions for cleanliness increases.

Your President claims to have reduced the cost of constructing tower clocks by using cast iron wheels as a substitute for those made from brass or other compositions, and there is not the slightest doubt but that cast iron wheels are cheaper than brass or gun metal ones, and that paint is a cheaper and better protection for the cast iron than lacquer is for the brass, and is equally good for the purpose. There is a wide difference, however, between a tower clock and a watch. They are the opposite extremes of horological instruments, and that kind of mechanical execution which may be well adapted for the one is totally unsuitable for the other.

We have one of Dent's small-sized tower clocks here in this city, which, I suppose, has been constructed according to the ideas of your President. I have often admired the beauty of the moulded wheels and the smoothness obtained in casting them. It occurs to me now that the price of these clocks might be still further reduced by using rougher castings and daubing them over with coal tar, which is cheaper than paint. Perhaps some people will say that this would not be an improvement, but I will maintain that it would be an equal improvement to the omission of what your President calls the useless polish in watches. But, again, some people may insist that the skilful moulder can produce smooth castings just as easily as he could make rougher ones, perhaps easier. So it is with the skilful watchmaker. He finds no difficulty, and uses but little time, in producing the polish after a grey surface has been produced; consequently, I must insist on my suggested improvements in tower clocks, if your President insists on his favourite improvements on watches, because smooth castings and fine paint do not improve the going of the clock. Will any man in the world venture to say they do?

It appears that on some other occasions your President laughed at the importance attached to facing pinions, and at that time asked, and he now asked again, "How many people in England have the most remote idea whether the pinions of their watches are faced or not, or even what it means?" Now, this looks more like talking to a meeting of "duffers" than reasoning before a body of intelligent watchmakers. If we are not to face pinions simply because the owners of the watches cannot see the work, on the same principle we might save the labour of hammering the brass, and even omit hardening some parts of the steel work, because the general public cannot tell the difference by looking at it; or that a botch may substitute brass for a jewel when the broken jewel is in a position where it is not seen, or that the stop work of a Swiss watch may be removed when it is out of order, instead of repairing it. It is one of the unfortunate circumstances connected with our profession that the majority of the wearers of watches understand nothing about them, while others may be possessed of that little knowledge which is so dangerous. Watchmaking and repairing has to be left entirely to the honesty and conscientiousness of those engaged in the business. The general public can only judge of their watches by the results they produce, but watchmakers must not omit any labour, however trifling it may be, that has a tendency to produce these results and maintain them after they are produced. In addition to the taste displayed in the operation, the facing is as essential to cleanliness as polishing any other part of the watch. Observing watchmakers must have noticed that when the face of a pinion is near to the shoulder of the pivot the oil on the pivot stands better when the face of the pinion is polished than when it is left rough, or even grey, and when working under the same conditions otherwise. For this reason, and also for the protection of the surfaces from rust and for general cleanliness, it is very important that the faces of pinions in watches should be polished.

Your President considers that the mechanical execution of horological instruments had been carried to its highest possible pitch before his day, and perhaps it had; but from the general specimens we see executed at the present day I would judge that that art was in great danger of being lost. In addition to the purely scientific department of the profession, your Institute cannot engage in a better work than in encouraging and developing skilful hand labour and elevating it to the position where it properly belongs; for what use is the educated head without the educated hand? There appears to be altogether too much antagonism between the scientific and practical branches of the business. Talented

scientific men may conceive ideas, but in all matters of detail the practical man is usually the best judge, and no person, whatever may be his position or his attainments, has any right to underrate the value of his services.

While not neglecting scientific progress, let us emulate our grandfathers in the quality of the work they produced. I do not insist that the means used be the same as they used. If we can find cheaper and better methods by all means let them be adopted, but let us strive to do the work as well as they did. As was truly remarked by a speaker at the meeting I have reference to, the object of your Institute should be to impart instruction that has a tendency to produce good watches rather than cheap ones. If really good watches could be produced at a cheaper rate than they are at present perhaps it might be better for all parties; but there appear to be quite enough of influences at work in the world to reduce the quality of watches without the British Horological Institute joining in the crusade.

In concluding these remarks I would notice a statement made by your President in regard to the Westminster clock. He asserts that this clock "goes better than any astronomical clock with the finest dead beat escapement that was ever made." Now, this is a very strong statement to make about any tower clock, but I suppose it is one that is susceptible of proof. After all the talk that has been about this clock I suppose it is not asking too much that an authentic extract of its rate for the period of a year should be published in your *Journal*. Let the comparisons be as frequent as astronomical clocks are usually compared, and let every alteration in the hands or in the length of the pendulum of the Westminster clock be duly noted. The average rate of astronomical clocks with dead beat escapements is well known, and should the rate of the Westminster clock prove in reality to be superior to the others it will throw a halo round your President's head that will last for ever.

CLYDE.

New York, U.S.A.,
March 26, 1874.

SIR,—As none of your correspondents have as yet taken any notice of the speeches given at the Mansion House, when the prizes were distributed to the exhibitors at the Horological Institute, I take the liberty to solicit space in the *Journal* for a few remarks, hoping and wishing that the subject will be taken up and well considered. I believe that it was said by Mr. Denison that to polish screws and pivots to great perfection was of very little use in watchmaking, and at any rate did not deserve a prize. I think it is of vital importance to the British Horological Institute, and to English watch and clockmakers, that every opportunity should be used to impress upon the minds of those who are to be watchmakers, that they can only learn the art by many long years of constant practice, and that great perfection in turning, filing, and polishing is absolutely required. As the object of the Horological Institute is to advance Horology, it should be taken under serious consideration if the old mode of teaching was wrong, and, if so, what method should be followed. That might, perhaps, give watchmaking one little push in the right direction, and for the reason that the art of watchmaking has not advanced much, to say the least, in England in late years. I know that it is said that, considering the time and trouble it takes to learn the trade of watchmaking, and the little that can be gained by it, it is of no importance if the business should leave the country altogether. The Horological Institute, however, can not look upon the question from that point of view; besides, watchmaking is an art so important that I think it would be well if something could be done so that apprentices could be obtained of a class different from those who now generally attempt to learn the art. One of the means to make good workmen is to encourage good and careful work, and not to make the young believe that a good and conscientious workman is not of more value than one who can only do rough work. In no business is it more dangerous than in ours not to make a distinction between good and bad work, because the public cannot judge. It is certainly a fact that good watchmakers are scarce; in fact, it is a rare chance to get an assistant now who knows his business. I have had a man asking for a situation who had served his time in what is considered a watchmakers' establishment, and with a good recommendation from his master, who, when I asked him if he could turn a pinion, told me that he could not turn at all. "They did not turn," he said, "in the shop I came from." I suppose his master thought that it is not necessary to be so particular as to turn pivots or screws—filing them would be near enough. I know that it will be said, and, in fact, has been said, that wheels, pallets, screws, and many other things are better if not filed and turned with sharp corners. In a Horological point of view it is not so; besides, that does not concern those who are to learn, any more than it concerns one who is to learn music whether Mendelssohn is a better composer than Meyerbeer or not. I say that the young

who are to be watchmakers should have it instilled into their mind from the beginning, and strictly kept to it, that watchmaking means the highest perfection, and should never be told that a piece of work is good enough when it could be better.

Yours, &c.,

CHRISTIAN LANGE.

99, Strand.

Sir,—I beg to inform you of a little mistake in the last number of the *Horological Journal*. The chronometer that had the highest place at the Greenwich trials, 1870, had no auxiliary to the compensation. An improved compensation was obtained by giving the balance such a form that the compensation rims were more than double the usual length. By a due attention to length and thickness of the rims, auxiliaries become unnecessary.

I am, Sir, &c.,

F. KNUDSEN.

Sir,—The article in the *Journal* for this month, by G. Lund, Esq., is a very interesting one, especially so to those who are more or less engaged in the construction of chimes; nor do I think anything could be more worthy their attention. No doubt the want of a perfect system of damping in our chime and musical clocks is the great cause of so few being made at the present day, and if by any means something could be done to prevent the horrid jingle of the bells, that branch of our trade might revive. I am persuaded that nothing could be sweeter than music from bells if bass notes and runs could be introduced free from a confusion of sounds, and, as damping after each note has rung out its proper time is the one thing wanted, I wish to offer a suggestion which, in my humble opinion, would have the desired effect. Now, for simplicity of explanation, I will suppose the barrel is of such size as to allow a space of $\frac{1}{16}$ inch for the shortest note, and that a quaver—time 3 crotchets in a bar—the space required for a crotchet is double that of a quaver, and would, therefore, be $\frac{1}{8}$ inch; but there is in the tune here and there a dotted minim forming a whole bar, and the space of a minim would, of course, be $\frac{3}{8}$ inch; here comes the difficulty, viz., of allowing the note to sound whilst the barrel is going through the required spaces, and then to cease instantly, and this, I feel assured, could be done effectually by applying an additional barrel running by means of one wheel of the same number and size attached to each; the one in front of the bells to give out the tune, the other behind bearing upon it lengths of metal, corresponding to the lengths of spaces in the tune barrel, which may easily have dampers so applied as to keep clear of the bell for the proper period of each differing note, and instantly fall upon it at the proper time, and by this means I think we might have the sweetest of music from bells. Had I time and convenience I should certainly try the experiment.

I am, Sir, &c.,

H. WIGNALL.

Burnley, April 20th.

To Correspondents.

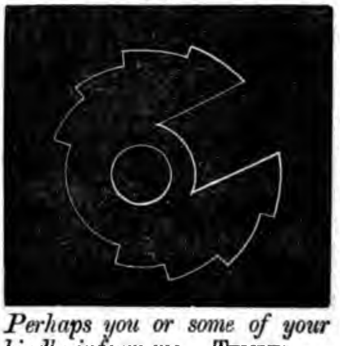
J. G.—*We know of nothing but the series of articles commenced in the November number of our own Journal.*

Can any reader furnish me with the address of anyone of whom I could get a drawn zinc tube for a clock pendulum?—J. P.

Will some reader have the kindness to inform me, through the columns of the Journal, of the best possible way of altering the pallet angle of a verge without the fear of breaking? I find that many verges have the pallet angle very wide when they ought to be at right angles. I have altered some by twisting the verge, but that is a very risky way, so I would like to know of a safer way of doing it.—C. G.

I beg leave to say that I had a watch which behaved in just the same way as the one referred to by "C. M." in the number for March last. Everything appeared to be right, except that the staff pivots were thick in proportion to size of balance; these I reduced to a proper size, put in jewels to suit, and the watch has gone well ever since, which is three years ago.—G. S.

I have lately met with a 30-hour clock, from which the striking part had been removed, the snail was of the enclosed sketch.



I am at a loss to know for what purpose a clock with such a snail could have been designed. Perhaps you or some of your readers would kindly inform me.—Tempus.

ON AN IMPROVED METHOD OF CONSTRUCTING THE DEAD-ESCAPEMENT FOR CLOCKS.

By BENJAMIN LEWIS VULLIAMY, Clockmaker to the Queen, &c.

The Council have decided, with the permission of Mr. George Vulliamy, to reproduce the following essay, now unobtainable. The dead-escapement has for many years held the first place as an escapement for regulators, &c., and indeed is without rival now, if we except Denison's three-legged gravity, which appears to have been adopted by some makers in preference. Some portions of the memoir may appear slightly antiquated, but the precision obtained by Mr. Vulliamy's method of manufacturing the escapement and the generally scientific treatment of the theoretical portion quite justify the Council in giving this treatise a place in the standard literature of the art:—

The dead-escapement originally invented by G. Graham, F.R.S., being perhaps practically the best clock escapement known, any improvement in the method of executing it, whereby the practice is made more exactly to agree with the theory than has hitherto been the case, may not be unworthy of notice: The principle of the dead-escapement is well-known; the motion of the pendulum is maintained by the action of the wheel on the inclined planes of the pallets, which occupy a portion of the arc of vibration of the pendulum, equal to the angle of the pallets; during the remainder of the vibration, the tooth bears on the circular parts, or rests of the pallets, which are portions of two circles, concentric with the axis of the verge, or centre of motion of the pallets, and consequently there ought not to be any recoil in the escapement, if properly executed. Various constructions and shapes of pallets and pallet-frames, each supposed to possess some peculiar advantage, have, at various periods, been adopted; but the whole have been executed with the file. The construction of the dead-escapement, of which the following is a description, and which I have employed, is, with the exception of the inclined planes of the pallets, and forming the frame out of the turned piece or pieces, entirely executed in the lathe; and if the parts are accurately turned with a slide-rest, must, of course, possess a degree of precision, independent of its other advantages, which pallets executed with the file cannot possess.

Fig. 1, of which Fig. 2. is a section, represents a circular brass plate, with a square groove, A. B, turned in it. Fig. 3, represents a steel ring, of which Fig. 4, is a section, turned very exactly of width and thickness to fit perfectly into the groove, A B, portions of which form the pallets. Fig. 5, represents the pallet frame made out of the circular piece of brass, represented Fig. 1, and L and M, Figs. 2, 5, and 8, are two pieces, fixed with screws to the frame to retain the pallets immovably in the grooves. Figs. 6 and 7, represent each a pair of pallets, made of part of the steel ring, the one with short, the other with long, inclined planes; 1, 2, & 3, 4, are the inclined planes of both pair of pallets. Fig. 8, represents the pallets placed in the frame, and held firmly in their places by the pieces L and M. The preferable mode of making the pieces, L and M, is out of the extremity of a piece of what remains of the piece, Fig. 1. after the pallet-frame is formed, reduced to a proper thickness, because the end of the piece is of necessity a portion of the same circle as the end of the arm.

Figs. 1 and 2.

Figs. 3 and 4.

In the common construction of pallets there is no method of opening and closing the

Figs. 6 and 7.

pallets to the wheel, but by filing the inclined planes, of faces, of the pallets to open them, and bending the arms to close them; to obviate this inconvenience, jointed pallet-frames have been adopted; but these, unless planned and executed with more than common care, are as defective in principle as in execution. In the construction of the pallets above described, the pallet-frame is not] jointed, but made of a single piece, and there is no adjustment in the frame for opening and closing the pallets to the wheel; but the same end may be obtained, though not in the most perfect manner, by loosening the pieces L and M, (see Fig. 8,) by which the pallets are held fast in the frame, and pushing the pallets backwards and forwards in the groove. This, though infinitely better than the old method, is not easy, it being difficult in practice to remove the pallets a very minute quantity; and to open or close the pallets by this method, it is necessary to disengage the pallet-frame, and all the parts to which it is attached, from the frame of the clock, an inconvenience which is entirely obviated by the method about to be described.

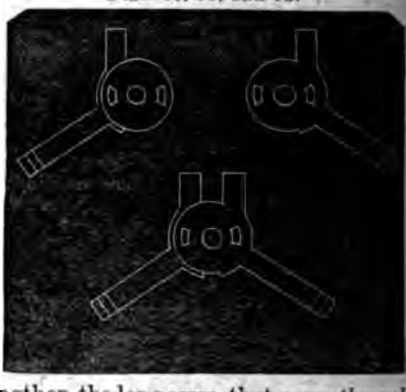
Figs. 5 and 8.

To remove this difficulty, the following mode of constructing the pallet-frome may be adopted. It admits of the pollet-frame being made jointed upon the same principle, and with equal accuracy; and the opening and closing of the arms being regulated by a screw, their quantity of motion may be infinitely small, and determined to the greatest nicety. For this purpose a second piece, exactly similar to the piece represented, Fig. 1, is required. See Fig. 9, of which Fig. 10 is a section.

When the pallet-frame is intended to be made jointed, the sink, E F, represented in the section Fig. 2, must be turned in Fig. 1, on the reverse side to the groove, A B, and a similar sink, E F, must be turned in the piece, Fig. 9, on the same side as the groove. See Fig. 10. It is requisite those sinks should be exactly the same size, and in depth half the thickness of the piece. The two circular pieces, Figs 1 and 9, being of equal thickness, and the sinks each equal to half the thickness of the piece in which it is turned, it necessarily follows that when the surfaces of the two sinks are brought together, they will equal in thickness the remaining part of either piece. That this should be the case is indispensable to the correct performance of a jointed pallet-frame, made on this construction. Perhaps the best mode in practice to make the sinks equal, is to turn a piece of brass as a guage, to let into the pieces, Figs. 1 and 9, which will ensure the sinks being in every respect the same. The section of such a piece is shown, W, Fig. 10. Exactly half the pallet-frame is formed out of each of the pieces, Figs. 1 and 9, and the two halves are represented, Figs. 11 and 12, and the two put together are represented, Fig. 13. To strengthen the long arms that carry the pallets, there is to each half of the frame a portion of the original piece left concentric to the sink, which forms a connexion between the upper surfaces of the long and short arms; and to strengthen the long arm it is continued a little below the arm. By this means the strength of the frame is greatly increased, and the fitting together of the two arms does not entirely depend on the good fitting of the holes through their centres, on the steel cylinder, or verge, that passes through the common centre of the two. This is shown more plainly in Fig. 11, than in Fig. 12, the whole surface

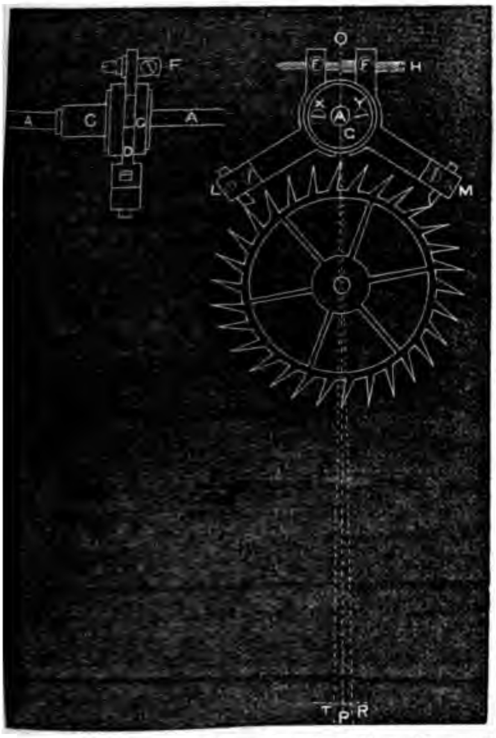
Figs. 9 and 10.

Figs. 11, 12, and 13.



of Fig. 12, being on the side represented in the figure on one plane, whereas in Fig. 11 (on the side represented in the Figure), the two arms and connecting part are on one plane, and the sunk part represented by the complete circle on another, half the thickness of the piece below the upper plane. The manner of fixing the pallets to the axis of the verge connecting the two arms together, and opening and closing them, is represented in front, Fig. 15 and in profile, Fig 14. A A, Fig. 14, is part of the verge, to which is immovably fixed the collet, C, with a long socket; D is the pallet-frame, and G a collar in front of the frame. These parts are held together by the two screws, X and Y, Fig. 15, which are tapped into the collar, C, Fig 14, and exactly fit the holes they pass through in the collar, G. By this means the two arms forming the pallet-frame are held together, and firmly fixed

Figs. 14 and 15.



between the collet, C, and the collar, D, and consequently attached to the verge, A A. It is to be observed, that the screws, X and Y, must not be screwed so tight that the regulating screw, H, has not power to overcome the friction of the arms of the pallets between the collet, C, and the collar, G, for in that case the whole intention of the jointed pallet-frame would be frustrated. To enable the arms to open and close, there are two circular notches in the same places in each half of the pallet-frame, concentric with the centre (see Figs. 11, 12, and 13), through which the two screws, X and Y, Fig. 15, pass, and the quantity of motion of the arms is determined by the length of the circular notches. The two studs, F and F, Fig. 15, through which the requlating screw, H, passes, are connected with the upper arms of the pallets by pivots, which pass through them, and are held in their places with collets and screws.—See Fig. 14. Care must be taken not to screw the studs so tight as to prevent their turning on their centres, otherwise the regulating screw, H, will be bound. This screw, H, being of two different threads, the one coarser than the other, thereby producing a very fine motion, has the effect, when turned in one direction, to open the pallets; and turned in the other, to close them.

The great advantage in this mode of construction are, 1st, That the rests of the pallets are correct portions of circles, the centre of which circles is the centre of motion of the axis of the verge, and the pallets move in the same circles, and, consequently, there will not be any recoil in the escapement. 2nd, That the pallets must be of equal thickness, and consequently the drop the same on both. 3rd, That the pallets may be made perfectly hard, if properly treated, without risk of altering their shape: and should a pallet be spoiled by any accident in hardening, or a flaw or imperfection of any kind be discovered, another exactly similar is easily made to replace it out of the original ring. When the pallets are made out of the same piece of steel as the arms of the frame, it is difficult to preserve their shape correctly in hardening, and to retain the acting part of the pallet perfectly hard. To obviate this difficulty, the pallet has sometimes been made a separate piece, with a short arm, by which it is fixed with two screws to the arm of the frame; but this is only to exchange one evil for another, for, independent of other disadvantages, which it is unnecessary to enumerate, it is very uncertain, with the pallets fixed in this manner, whether or not the rests of the pallets are concentric with the centre of the axis of the verge. The slightest deviation from its original direction in the arm of the pallet, by hardening or any other cause, has the effect of removing the centre of the circle, forming the rests of the pallets; from the centre of the axis of the verge to some other place, the consequence of which is to render the escapement a recoil escapement. 4th, That the mode here recommended of constructing the pallets, offers a great facility for making the inclined planes of the pallets equal to one another, or of altering

them as may be required; and consequently the angle which the pendulum is led by one pallet, will be equal to the angle it is led by the other.

Figs. 14 and 15, as before mentioned, represent the jointed pallet-frame in profile and in front, with all its parts complete, attached to the verge, and the pallets in their places. To Fig. 15 is added the scape-wheel, and the pallets are represented in the situation in which they will appear, when the wheel has led the pallet to the extremity of the lead. The angles of lead (more particularly noticed hereafter) of the pallets being each supposed equal to an angle of 2°, it follows that the pendulum is led 1° on each of the perpendicular line, O P, by the action of the escapement, and that the wheel will escape when the pendulum vibrates the smallest quantity more than 1° on each side of the line it subtends when at rest. Now, supposing the arc of vibration of the pendulum to be 5°, that is 2° 30′ on each side of the perpendicular, and the angle of lead of the pallets 2°; the tooth of the scape-wheel rests

Fig. 16.

3° on the rests of the pallets, 1° 30′ on each rest, during each vibration of the pendulum, the pendulum vibrating an angle of 5°. From the above, the great importance of the rests of the pallets being concentric to the centre of motion of the axis of the verge, is sufficiently obvious. The line, O P., Fig. 15, passing through the centres of the axis of the verge and the axis of the wheel, is the line the pendulum subtends when at rest, and the lines, A R and A T, forming together the angle, R A T, supposed of 2°, are the lines the pendulum will subtend, when led to the extremity of the lead by the action of the wheel upon each pallet. In Fig. 15, the pendulum is supposed to subtend the line A T.

The following is a brief description of a method by which the inclined planes of the pallets are finished to the required angle.

Fig. 16 represents a brass plate, about three or four inches in diameter, the size is not very material, and about two inches thick, with a groove turned in it similar to the groove, A B, Fig. 1. The angles, B A C, and D A E, are drawn equal to the proposed angles of lead of the pallets, and in this case are supposed angles of 2°. To determine the line of the face of the inclined planes of the pallets, from the points, G and H, where the lines, A B and A D, intersect the exterior circle of the groove, draw the lines, G I and H K, which may be considered as chords subtending equal arcs, intersecting the lines, A C and A E, at the points, L and M, the inner circle of the groove; the lines, G L and H M, may, relative to the two circles of the groove, be considered as representing the inclined planes of the pallets. Now, supposing that portion of the original piece of brass subtended by the chord, X Y, carefully removed, and the surface made perfectly flat, and at right angles to the turned face in which is the groove, it follows that a piece of the steel ring, Fig. 3, one end of which has been brought, by filing very near to the required angle, may be placed in the groove, and ground and finished in the most accurate manner. By this method, the surface of the pallet will be made perfectly correct. The other pallet may be finished by a similar method.

It may not be unnecessary to observe, for the preservation of the figure, that the principal bearings of the tool should not come in contact with the grinding surface during the operation.

The Emperor Charles V., who had a watch or as some have called it a small table-clock, in 1530, on his retirement subsequently into the monastery of St. Juste or Yuste, under the influence of a religious monomania, used to sit after dinner with several on the table before, him, his bottle being in the centre; and endeavour to amuse his dejected mind by trying to make his portable clocks accord—a vain task, as he found, and productive only of a salutary moral reflection on his brain, which shaped itself into the following pithy words: —"What an egregious fool must I have been to have squandered so much blood and treasure in an absurd attempt to make all men think alike, when I cannot even make a few watches keep time together."

OCCLUSION OF GASES BY METALS.

(From the "Smithsonian Report.")

THE experiments of Deville and Troost having made known the curious fact of the permeability of ignited homogeneous platinum and ignited homogeneous iron to hydrogen gas, and given some indication also of the permeability of ignited iron to carbonic oxide gas, Mr. Graham, in 1866, corroborated the results of the French chemists in reference to platinum; but, modifying their method by letting the hydrogen pass into a space kept vacuous by the Sprengel pump, instead of into an atmosphere of other gas, assimilated the process to that which he had employed in his India-rubber experiments. The results he obtained were communicated to the Royal Society, partly in the paper already referred to "On the Absorption and Separation of Gases by Colloid Septa," and partly in four supplementary notices published in the proceedings of the society.* In carrying out the investigation forming the subject of these several communications, Mr. Graham had the advantage of being admirably seconded by his assistant, Mr. W. Chandler Roberts, whose able and zealous co-operation he repeatedly acknowledged in the warmest terms.

In the course of experiments made on the transmission of gases through ignited metallic septa, a particular platinum tube, being rendered vacuous, was found at all temperatures below redness to be quite impermeable to hydrogen; whereas, at a red heat, it transmitted 100 cubic centimeters of hydrogen in half an hour, the quantities of oxygen, nitrogen, marsh gas, and carbonic gas, transmitted under the same conditions, not amounting to ·01 cubic centimeter each in half an hour. It was ascertained further that, with an ignited vacuous tube of platinum surrounded by a current of ordinary coal gas (a variable mixture of gases containing on the average about 45 per cent. of marsh gas, 40 per cent. of hydrogen, and 15 per cent. of other gases and vapours), a transmission of pure hydrogen alone took place through the heated metal. This property of selective transmission, manifested by platinum, was so far analogous to the property of selective transmission manifested by India-rubber, that whereas a septum of India-rubber transmitted the nitrogen of the air in a much smaller ratio than the oxygen, the septum of ignited platinum transmitted the other constituents of coal gas in an infinitely smaller ratio than the hydrogen. Hence the knowledge of absorption by India-rubber of the gases which it most freely transmitted, suggested to Mr. Graham an inquiry as to the possible absorption of hydrogen gas by platinum. Accordingly platinum, in different forms, was heated to redness, and then allowed to cool slowly in a continuous current of hydrogen. The metal so treated, and after its free exposure to the air, was placed in a porcelain tube, which was next made vacuous by the Sprengel pump. During the production and maintenance of the vacuum, no hydrogen was extracted from the metal at ordinary temperatures; or even during an hour's exposure to the temperature of 220°; or yet at a heat falling just short of redness. But at a dull red-heat and upward, a quantity of hydrogen gas was given off amounting in volume, measured cold, to as much, in some cases, as 5·5 times the volume of the platinum. Thus was opened out to Mr. Graham the subject of his last, and probably greatest, discovery, the occlusion of gases by metals. Very many metals were examined in their relations to different gases, but the most interesting results were those obtained with platinum, as above described; and those obtained with silver, with iron, and, above all, with palladium.

The characteristic property of silver, heated and cooled in different atmospheres, proved to be its capability of absorbing and retaining, in some cases, as much as seven times its volume of oxygen—its absorption of hydrogen falling short of a single volume. Some silver-leaf, heated and cooled in ordinary air, and subsequently heated in a vacuum, gave off a mixture of oxygen and nitrogen gases containing 85 per cent. of oxygen, or more than four times the proportion contained in the original air. This remarkable property of solid silver to effect the permanent occlusion of oxygen gas, must be distinguished from the not less remarkable and doubtless associated property of melted silver to effect the temporary absorption of a yet larger volume of the same gas; which, on the solidification of the metal, is discharged with the well-known phenomenon of spitting.

Iron, though tolerably absorptive of hydrogen, was found to be specially characterised by its absorption of carbonic oxide. What may be called the natural gas of wrought iron, or the gas derived from the forge in which it was heated, proved to consist chiefly of carbonic oxide, and, in different experiments, was found to range from 7 to 12·5 times the volume of the metal; so that, in the course of its preparation, iron would appear to occlude upward of seven times its volume of carbonic oxide, and to carry this gas about with it ever after. The absorbability of carbonic oxide by iron has an ob-

* Royal Society Proceedings, xv., p. 502; xvi. p. 422; xvii., p. 212, p. 500.

viously important bearing on the theory of steel production by cementation. This process would appear to consist in an absorption of carbonic oxide gas into the substance of the iron and in a subsequent decomposition of the absorbed gas into carbon entering into combination with the metal, so as to effect its acieration, and carbonic gas discharged from the surface of the metal, so as to produce the well-known appearance of blistering. Nor is this the only, or even the chief, point of interest that was made out with regard to iron; for the study of the behaviour of telluric manufactured iron naturally led Mr. Graham to the examination of sidereal native iron, that is to say, the iron of meteorites, and with the following result. A portion of the meteoric iron, from the Lenarto fall, when heated *in vacuo*, gave off 2·85 times its volume of natural gas, of which the preponderating constituent, to the extent of 85·7 per cent. of the total quantity, consisted not of carbonic oxide, but of hydrogen, the carbonic oxide amounting to only 4·5 per cent., and the remaining 9·8 per cent. consisting of nitrogen. The inference that the meteorite had been, at some time or other, ignited in an atmosphere having hydrogen as its prevailing constituents, seems irresistible; and judging from the volume of gas yielded by the iron, the hydrogen atmosphere in which it was ignited must, in all probability, have been a highly condensed one; the charge of hydrogen extracted being fully five times as great as it was found possible to impart to ordinary iron artificially.

But it was with palladium that Mr. Graham obtained his most extraordinary results. This metal he found to have the property of transmitting hydrogen with extreme facility, even at temperatures very far short of redness. Coincidently, at temperatures even below those requisite for transmission, palladium was found capable of absorbing many hundred times its volume of hydrogen. Thus a piece of palladium foil maintained at a temperature of 90°-97° for three hours, and then allowed to cool down during a hour and a half, while surrounded by a continuous current of hydrogen gas, gave off, on being afterward heated *in vacuo*, 643 times its volume of the gas, measured cold; and even at ordinary temperatures, it absorbed 376 times its volume of the gas, provided it had first been recently ignited *in vacuo*. In another experiment, palladium sponge, heated to 200° in a current of hydrogen and allowed to cool slowly therein, afterward yielded 686 times its volume of the gas; while a piece of electrolytically deposited palladium heated only to 100° in hydrogen, afterward yielded, upon ignition *in vacuo*, no less than 982 times its volume of the gas. The lowness of the temperature at which, under favourable circumstances, the absorption of hydrogen by palladium could thus be effected, soon suggested other means of bringing about the result. For example, a piece of palladium-foil was placed in contact with a quantity of zinc undergoing solution in dilute sulphuric acid; and, on subsequent examination, was found to have absorbed 173 times its volume of hydrogen. Again, palladium, in the forms of wire and foil, was made to act as the negative pole of a Bunsen's battery effecting the electrolysis of acidulated water; and in this manner was found to absorb from 800 to 950 times its volume of hydrogen in different experiments.

Palladium being thus chargeable with hydrogen in three different ways—namely, by being heated and cooled in an atmosphere of the gas; by being placed in contact with zinc dissolving in acid, *i. e.*, with hydrogen in the act of evolution; and, lastly, by being made the negative electrode of a battery—correlatively, the charged metal could be freed from its occluded hydrogen by exposing it to an increase of temperature in air or vacuo; by acting on it with different feebly oxidizing mixtures; and by making it the positive electrode of a battery.

The palladium, when charged to its maximum, was frequently found to give off a small proportion of its hydrogen, though with extreme slowness, at ordinary temperatures, both into the atmosphere and into a vacuum. But not until the temperature approached 100° was there any appreciable gas-evolution; which, above that point, took place with a facility increasing with the temperature, so as to be both rapid and complete at about 300°. Since, however, the transmission of hydrogen through heated palladium is a phenomenon of simultaneous absorption and evolution, it follows that the property of palladium to absorb hydrogen does not cease at 300°, or indeed at close upon the melting-point of gold—the highest temperature at which Mr. Graham's experiments on transmission were conducted; but whereas the maximum absorption of hydrogen by palladium takes place at comparatively low temperature, the velocity of transmission was observed to increase, in a rapid ratio, with the increase of temperature, indefinitely.

As regards the removal of hydrogen from palladium by oxygenants, the gas of the charged metal was found to manifest all the chemical activity of hydrogen in the nascent state. Thus it reduced corrosive sublimate to calomel, combined directly with free iodine, converted ferrid into ferro cyanides, destroyed

he colour of permanganates, &c. Moreover, he spongy metal, charged with hydrogen and xposed to the air, was apt to become suddenly ot, and so completely discharged, by a sponaneous aerial oxidation of its absorbed gas nto water; while the hydrogen of a piece of harged palladium wire was often capable of eing set fire to, and of burning continuously long the wire.

Lastly, the reversal of the position of the palladium plate in the decomposing cell of he battery afforded a most ready means of ompletly extracting its hydrogen. Indeed, or some time after the reversal, while hydrogen was being freely evolved from the negaive pole, no oxygen was observable on the surface of the palladium plate, now made the positive pole, through its rapid oxygenation f the absorbed hydrogen.

As regards the extent of the absorption f hydrogen by palladium, it was found, as lready indicated, to vary considerably with he physical state of metal, whether fused, ammered, spongy, or electrolytically deosited, for example. In one case, previously eferred to, a specimen of electrolytically deosited palladium, heated to 100°, and then lowly cooled in a continuous current of ydrogen, was found to occlude 982·14 times ts volume of the gas, measured cold. In his case the actual weight of palladium exerimented with was 1·0020 gram, and the veight of hydrogen absorbed ·0073 gram, eing in the ratio of 99·277 per cent. of palladium and 0·723 per cent. of hydrogen. The atomic weight of hydrogen being 1, and hat of palladium 106·5, it is observable that he ratio of the weights of the constituents of he charged metal, hydrogen and palladium, pproximates to the ratios of their atomic veights.

In another experiment some palladium vire, drawn from a piece of the fused metal, vas charged electrolytically with 935.67 imes its volume of hydrogen. Some idea of hese enormous absorptions of hydrogen may e formed by remembering that water at nean temperature absorbs only 782·7 times ts volume of that most absorbable of the ommon gases, ammonia.

A point of interest with regard to the ifferent quantities of hydrogen absorbable y palladium in its different states is the radual diminution in the absorptive power f any particular specimen of the metal with ach successive charge and discharge of gas n whatever way effected—the absorptive ower, however, being partially restorable y subjecting the metal to a welding heat.

The density of palladium charged with eight r nine hundred times its volume of hydrogen is perceptibly lowered. Owing, however, to a continuous formation of bubbles of hydrogen on the surface of the charged metal when immersed in water, there is a difficulty in taking its exact density by comparing its respective weights in air and water with one another. There is also a difficulty in determining the density by direct measurement of the charged palladium when in the form of wire; owing to the curious property of the wire, on being discharged, of not merely returning to its original volume, but of undergoing a considerable and permanent additional retraction. But in the case of certain alloys of platinum, silver, and gold with excess of palladium, while the absorptive power of the constituent palladium is still manifested, the excess of retraction on discharge of the wires does not occur; and the specific gravities deducible from the mere increase in length of wires of these alloys are found to accord approximatively with those deducible from the increase in length of the pure palladium wire, not above its original length, but above the length to which it retracts on discharge of its absorbed gas. It would thus appear that, simultaneously with its absorption of hydrogen, the pure palladium wire, unstably stretched by the process of drawing, suffers two opposite actions; that is to say, it undergoes a process of shortening by assuming a more stable condition of cohesion, and a process of lengthening by the addition to it of other matter—the lengthening due to the additional matter being the excess of the length of the charged above that of the discharged wire. In a particular experiment illustrative of this peculiarity, a new platinum wire took up a full charge of hydrogen electrolytically, namely, 956·3 volumes, and increased in length from 609·585 to 619·354 millimeters. With the expulsion of the hydrogen afterward, the wire was permanently shortened to 600·115 millimeters. The sum of the two changes taken together amounts to 19 239 millimeters, and represents the true increase in the length of the wire due to the addition of hydrogen. It corresponds to a linear expansion of 3·205 in 100, or to a cubical expansion of 9·827 in 100. The original volume of the wire being ·126 cubic centimeter, the volume of the condensed hydrogen would accordingly be ·01238 cubic centimeter. Then, as the charged wire, on being heated *in vacuo*, evolved 120·5 cubic centimeters of hydrogen gas, weighing ·0108 gram, the density of the absorbed hydrogen would be $\frac{\cdot0108}{\cdot01238}$ = ·872. Calculated from the mere increase in length of the charged wire above that of the wire originally, the density of the absorbed hydrogen would be 1·708. The following table gives

the densities of condensed hydrogen in different experiments made with palladium wire, in which the excess of retraction on discharge was allowed for as above; and also the densities observed in experiments made with palladium alloys in which the contraction on discharge took place to the original lengths of the wires only:—

When united with	Density of condensed hydrogen.
Palladium	0·854 to 0·872
Palladium and platinum	0·7401 to 0·7545
Palladium and gold	0·711 to 0·715
Palladium and silver	0.727 to 0·742

Whether the absorption of hydrogen by palladium, alloyed or not with another metal, was large or small, the density of the occluded hydrogen was found to be substantially the same. That the excessive retraction of the palladium wire on the discharge of its absorbed hydrogen is not a mere effect of heat was shown by the charged wire undergoing a similar retraction when discharged electrolytically instead of by ignition *in vacuo*, and also by the original wire not undergoing any sensible retraction as a result of annealing. That the retraction is merely in length was shown by the absence of any difference in specific gravity between the original and the discharged wire. Very curiously, the shortening of the wire, by successive chargings and dischargings of hydrogen, would seem to be interminable. Thus the following expansions of a particular wire, caused by variable charges of hydrogen, were followed, on expelling the hydrogen, by the contractions recorded in the other column.

	Elongation in millimeters.	Retraction in millimeters.
First experiment	9·77	9·70
Second experiment	5·765	6·20
Third experiment	2·36	3·14
Fourth experiment	3·482	4·95
		23·99

The palladium wire, which originally measured 609·144 millimeters, thus suffered, by four successive chargings and discharging of hydrogen, an ultimate contraction of 23·99 millimeters, or a reduction of its original length to the extent of nearly 4 per cent., each increment of contraction below the original length usually exceeding the previous increment of elongation above the original length of the wire. The alternate expansion and contraction of palladium by its occlusion and evolution of hydrogen is ingeniously shown by a contrivance of Mr. Roberts, in which a slip of palladium-foil, varnished on one side, is made to curl and uncurl itself, as it becomes alternately the negative and positive electrode of a battery, or is alternately charged and discharged of hydrogen on its free surface.

That hydrogen is the vapour of a highly volatile metal has frequently been maintained on chemical grounds; and from a consideration of the physical properties of his hydrogenised palladium, Mr. Graham was led to regard it as a true alloy of palladium with hydrogen, or rather hydrogenium, in which the volatility of the latter metal was restrained by the fixity of the former, and of which the metallic aspect was equally due to both of its constituents. Although, indeed, the occlusion of upward of 900 times its volume of hydrogen was found to lower the tenacity and electric conductivity of palladium appreciably, still the hydrogenised palladium remained possessed of a most characteristically metallic tenacity and conductivity. Thus, the tenacity of the original wire being taken as 100, the tenacity of the fully charged wire was found to be 81·29; and the electric conductivity of the original wire being 8·10, that of the hydrogenised wire was found to be 5·99. In further support of the conclusion arrived at by Mr. Graham, as to the metallic condition of the hydrogen occluded in palladium, he adduced his singular discovery of its being possessed of magnetic properties, more decided than those of palladium itself, a metal which Mr. Faraday had shown to be "feebly but truly magnetic." Operating with an electro-magnet of very moderate strength, Mr. Graham found that while an oblong fragment of electrolytically deposited palladium was deflected from the equatorial by 10° only, the same fragment of metal, charged with 604·6 times its volume of hydrogen, was deflected through 48°. Thus did Mr. Graham supplement the idea of hydrogen as an invisible incondensable gas, by the idea of hydrogen as an opaque, lustrous, white metal, having a specific gravity between 0·7 and 0·8, a well-marked tenacity and conductivity, and a very decided magnetism.

Very advantageous exchanges of watches are sometimes made by Europeans with the Chinese, many of whom ignorantly suppose that when a watch stops it is dead. Baker, in his work on the "Albert N' Yanza," says during his travels, commencing in 1861, a native named Kamrasi, "produced a large silver chronometer that he had received from Speke. 'It was dead,' he said, 'and he wished me to repair it.' This I declared to be impossible. He then confessed to having explained its construction, and the cause of the 'ticking' to his people, by the aid of a needle, and that it had never ticked since that occasion."

ON BELLS, AND MODERN IMPROVEMENTS FOR CHIMING AND CARILLONS.

[A Paper read before the Members of the Society of Arts.]

By GEORGE LUND, Esq.

I shall now proceed to give a description of the machine at Ipswich, and, as I propose to show you the principal improvements which we have made from stage to stage of our progress, I must preface my remarks upon this part of my subject by referring to the first machine we made, which we do not now use. Its great defect—and one which invariably proves fatal to accurate time-keeping in any self-acting instrument which has rough work to do—is that the barrel is made to revolve by means of an outside driving wheel fixed on to the main shaft of the weight drum, and geared into a wheel of a similar number of teeth, and upon the shaft of which was fixed what is called the carrying arm, which carries round the musical barrel one revolution of the drum, this being equal to one of the barrel. Let the pivots of these two shafts fit the holes in which they work, and let the depths of the wheels be pitched as accurately as possible, and the working of the teeth one into the other be quite perfect tooth and space, and yet in a very short time wear will begin to show itself, the wheels will begin to rock, and the machine for time-keeping purposes becomes no better than one constructed upon the old principle. A barrel which can be set back by any unusual pressure cannot keep good time, for it not only retards the note which it is discharging, but with the spring it gets with the set back it shoots forward to the next pin, and discharges it as much too soon as the last one was too late. This will be evident to the most casual observer. This machine is constructed to strike the hours and quarters, and to play a tune twice over every third hour with one weight and one train of wheels. There are three key-frames constructed in the same way as the key-frame of a self-acting organ, the key discharging the hammer on the bell instead of opening the valve as in an organ, as shown in diagram No. 5. Two are for the music, and one small one for the quarters, placed for convenience and saving of room in the centre of the two. They are all connected together, and are so arranged that when the two are down playing the music, the quarter frame is lifted, and the pins in the barrel cannot touch the quarter keys, and, *vice versa*, the quarter frame being down, the music-frames are up; the striking of the hours is also ingeniously arranged for, but to this I shall refer later on. As previously stated, we have abandoned the driving of the musical barrels by outside wheels, and now always drive them direct from the shaft upon which the weight drum works, and to which is fixed the main wheel of the machine, by making it project sufficiently through the bracket in which it works to allow of the carrying arm being fastened to it. The carrying arm is, as its name implies, that part of the machine which gives motion to, or carries round, the musical barrel, the main shaft passing into the centre of the barrel, and the carrying pin also entering it as near to the outer circumference as possible, both being accurately fitted, and the action of the barrel being only backwards and forwards. Not being circular, the wear, even in the course of years, is very trifling, and can be rectified at any time by simply putting a new back brass to the barrel. This was the first great improvement. Our next endeavour was to avoid, in the striking of the quarters, so much loss of fall of weight, one turn of the barrel, equal to the fall of two feet, being used for the striking of the quarters in one hour alone, in the first machine. We therefore separated the quarter barrel from the musical barrel, making the quarter barrel revolve only twice for the quarters of three hours, thus saving one turn, equal to two feet of fall, every three hours, equal to a saving of sixteen feet in the twenty-four hours, an enormous saving in such matters. In this machine, as in the first, the catches are released by a key in a key-frame, and a difficulty presented itself. How could we get over the pins discharging the hammers for the music at the same time as the quarters, without lifting the key-frame which is very heavy and cumbersome to deal with? We soon decided that a simple plan was to keep the musical barrel still till required to play the tune, by holding it free of the carrying pin in the carrying arm, and successfully accomplished it in this way. Instead of having a spring to bear on the end of the pivot of the barrel, we substituted a

weight working over a pulley and attached to a lever, by which it can be lifted or allowed to fall according to whether the barrel is required to revolve or not. We put a spring at the other end of the barrel, where the main shaft enters, so that when the weight is lifted this spring pumps the barrel away from the carrier, and it is held in the proper position for the pin to pick it up again the next third hour by a piece of steel in its outer edge entering a notched piece of iron. The weight when raised is held by a catch, which is withdrawn, just before the last quarter change at the hour is being struck, by a pin in the quarter barrel. It then falls and brings the musical barrel to bear against the end of the carrier pin till it reaches the notch cut in the brass rim; arrived there the machine stops, the barrel is drawn by the weight to the proper depth, according to the tune to be played, and it only awaits release from the clock at the last blow of the hour to start and play a tune through twice. This having been done, the weight is again raised by a small roller in the main wheel of the machine, and the barrel remains at rest for three hours more. There are seven tunes played, a different one at each third hour or not, at will; and here again the small barrel plays a simple, yet most important, part. The tunes are changed by shifting a seven-star snail, as in an ordinary musical box. This snail is shifted by a double action lever. A small roller is fitted to the carrying arm, which at each revolution comes in contact with the "V" shaped end of the lever, presses it down, and, so doing, raises the other end of the lever, which in its turn shifts the snail. To prevent this being done the first time round, a short spring lever is made to hold the pushing end of the snail-shifting lever away, and it is only when it is required to change the tune that a pin in the quarter barrel withdraws the spring lever, and allows the lever to work. The shifting lever end is made with a joint, so that by simply withdrawing it from contact with the snail the tune is not changed, although the spring lever may be withdrawn by the pin in the barrel. The quarter bell thus performs four distinct functions. It strikes the quarters, stops the machine when required, by a simple action—which I have thought it needless to explain—causes the music to be played at the proper times, and changes the tune or not, as desired; thus making it an automatic machine, it only being necessary that a small weight should be lifted by the clock and allowed to fall at each quarter of an hour, by which the machinery is started for the quarters, and a similar weight each third hour for the music. In the one case the weight is raised by four pins in a gun metal wheel fixed to the minute square of the clock, and in the other from the locking plate which regulates the striking of the hours. The improvements sought for in the construction of our next machine were these—to do away with the key-frame, which we thought unnecessary, both on account of the expensiveness of its manufacture and the drag we found it was upon the machinery. The discharge was not as easy as we could have wished it to be (although the machine still works admirably), and other minor details, such as to reduce the weight of the cam to do away with the hammers having to drag the weight of the levers after them, and so reducing their force of blows; and in other respects to give the machinery more life, or, more properly speaking, velocity, which performs a most important part in this machinery, the two main considerations being an easy and quick discharge, the most rapid lift attainable, so as to have as few hammers as possible on the lift at one time. The machine I am now about briefly to describe has been made for, and is now in course of erection at, High Beech Church, Epping, to the order of T. C. Baring, Esq. There are thirteen hemispherical bells in a tower nine feet square, and the machinery is placed in a room below. In a space of only nine feet square it would have been quite impossible to have got church bells of any size or of a sufficient number, and ringers could not have been found to use them. Hemispherical bells here exactly supply the want, and in making the machinery we desired that it should be no mere approach to the speed of changes as rung by ringers, but the exact speed should be given.

Ringers ring 28 changes per minute, which is 224 blows in the same time, and in order that not more than one hammer should be on the lift at once it was necessary to have a cam of that lifting power. The main wheel makes a revolution once a minute, consequently the discharging barrel which it drives from its shaft, as before described, makes a revolution in the same time; and to produce the needful correspondence between our wheels and pinions, and to give the proper interval between each pair of changes, exactly the same as ringers do, it was necessary to make our cam revolve 60 times to its once, and having four lifters, four times sixty (240) blows can be lifted per minute, more really than is required. I may here say that before making this machine we made a smaller one, which we here exhibit, and which we had in use for some time. The heaviest hammers to be lifted are about 20 lbs., for which the machinery need not be large. For larger machines we have

plans of a more powerful description, which we do not propose here to explain; suffice it to say that, be the weights what they may, we are prepared to deal satisfactorily with them. Having disposed of the number of hammers to be lifted, our next object was to do away with the unwieldy key-frame, and make a key and catch all in one, which should be quite easy of discharge and yet have holding power to its extreme point of discharge. This was not arrived at without much thought, one amongst many difficulties being to put them in such a position that the wooden barrel could be removed without disturbing them. This has been quite satisfactorily done; a catch has been constructed with all the requisite qualities in itself, and has been put in such a position that the barrel can be removed in a moment. We also here introduced a great improvement in the spring which draws in the pusher, by which the lever, to which is attached the bell hammer, is raised again to the catch which holds it. When the catch is discharged and the lever falls, it is, of course, necessary that the lever should not be again raised until the blow is struck upon the bell; and in order to do this, what we call a pusher, or cat's-paw, is attached to the lever, working freely on it, which is drawn into contact with the cam at the last moment in this way. It is, of course, a well-known mechanical law that there is much less action at the centre upon which anything works than at its extreme end. We therefore place a spring on an iron bar, which does three things. While the lever and hammer are held up it keeps the pusher against its banking pin; as the lever falls it keeps it pressed away from the cam till the last moment, when its bent end comes in contact with the cam, the next coming lifter of which lifts it to the catch, firmly held by which, all the weight of the hammer being gone from it, it flirts the pusher away to the banking pin till again discharged, when the process is repeated. Originally three separate actions were provided for this purpose. We consider these two improvements to be of the most important character, both as regards cost and efficiency. Other improvements were made, but not of sufficient importance to be referred to. It has two barrels, one of which has 296 changes on eight bells pricked on it, which will be used from 10.30 till 10.45, at which time that barrel will be taken out and one with 100 changes on 10 bells, three bell chimes and tolling, used at the discretion of the verger. A barrel can also be applied by which the hours and quarters can be struck the same as at Westminster; or, still further, a 7-tune barrel could be made, by which a different tune could be played through twice, at each hour, or the same at will, if the quarter-hour striking were found wearisome. To remove the barrel, all that is necessary is to move the spring which presses on the end pivot on one side, draw the barrel a little to the left, and out it comes, free of everything. There is also a key-board attached, by which Mrs. Baring can play on the bells as easily as she can play on a piano. This machine, therefore, is applicable for four purposes, chiming for the services of the church at any time, the striking part of a Cambridge quarter-clock, the playing of seven different tunes automatically, or a musical instrument to be played by hand. Some of my fellow-craftsmen here this evening may perhaps be sceptical, and say that I have as strong an imagination as the man who used to warm his hands by holding them round a candle-flame, but I can assure them it is quite true, and that I may perhaps have some further astonishments in store.

All our machinery is so constructed that any one part can be taken out for repair without disturbing any other, and even to every lever, and every catch, up to any number. The advantage of this plan was fully demonstrated in this way. After the machinery had been fixed at Ipswich some short time I had left it at nine o'clock on the Saturday evening, after it had chimed the quarters and played its tune twice over, and upon my return, at nine o'clock on Sunday morning—of course, you understand that I was only there to see all was right—to my great dismay I found that the heavy rain of the night before had run through an unstopped hole in the floor of the bell-chamber above, and that the machinery was most carefully watered all over. Of course by Monday red rust was everywhere where I had not been able to wipe it off the day before. A workman and myself began at seven o'clock on Monday morning. It only missed striking the quarters for two hours; it played as usual each third hour, and was as free from water and rust as ever it was by six o'clock the same evening, much of the steel work having been re-polished. Had it been needful to take all the machine to pieces at once, three days, at least, of silence would have been necessary.

It now only remains to explain the arrangements we have made in the larger of the two machines before you, for the several actions it has to perform. It will chime the Cambridge quarters and strike the hours (the same as the Westminster clock), and will play one of seven tunes every third hour, to be changed or not at will, as described in the others, with only one weight and one train of wheels. Clockmakers have always hitherto used three weights and three trains of wheels for the

same purpose. It will also be used for chiming for the services of the church of St. Mark, Victoria Park. As you see. there are two wooden barrels; one, the shorter, chimes the quarters and strikes the hours, and the longer will play the tunes or changes. The smaller barrel makes fifteen revolutions in twelve hours by means of a fifteen-stop snail, which is shifted one step forward by a carrying arm and double-action lever, one each turn, the same as used for altering the tunes, and before described. The quarters are also struck from it by means of keys and levers, connected with the four proper notes on the music side of the machine. By it are also struck the hours by a key and lever action, drawing in the hour-hammer lever in contact with the pins in the back of the main wheel of the machine, and holding it there sufficiently long for one or more blows to be struck on the bell, according to the hour. Immediately the last blow is struck the spring against which it was drawn throws the lever out of the way of the pins, and at each third hour a weight is dropped, and the musical barrel pushed in, it having stood still during the striking of the hours and quarters, as already described in the Ipswich machine. We have, however, greatly improved and strengthened the catch which holds up the lever to which the weight is attached, and have made the lever to fall free of the lifting pins in the face of the main wheel, so that by removing the jointed end of the snail-shifting lever, and moving forward the small barrel snail to a stop in which there are no pins, as occurs in that part of it which comes into action every third hour, changes of music can be played for any desired length of time, without the weight being raised and the barrel being pushed out of action, after the second time round, as it would be in the ordinary way. In the Ipswich machine, the shorter wooden barrel is a three hour locking plate for hours and music only; in this it becomes a twelve hour rapidly revolving locking plate, for hours, quarters, and music, than which there is no simpler or safer mode of stopping in clockwork or any self-acting machinery. A slow one is, however, very little use. In the intervals defined by this locking plate, pins will be put, which will either act upon the four quarter keys, the hour lever key, or the key which discharges the weight for the playing of the music, and causes it to be raised again when it should cease, one key serving both purposes, according to whether quarters or hours are to be struck or played.

Messrs. Charles Frodsham and Co., clock-makers, are making the timepiece, which will show the time on three dials, and start the machinery every quarter of an hour. We are also engaged upon the manufacture of a smaller machine for ten small hemispherical bells, the stable turret into which they will go being only 4ft. 6in. square by 8ft. high, which, with change of barrel, will either strike the hours and quarters, or play one of seven tunes twice over every hour, or as often as desired; a key-board for playing by hand will also be added. We are also planning a Cambridge quarter clock, which will only require one weight, instead of the two ordinarily used, for a larger tower, hemispherical bells again carrying off the palm. The advantages which we claim for our method of carrying out this patent are :—Extreme simplicity of all the parts of action; lightness of all the several parts, yet perfect strength and durability; high finish and accuracy (and upon this point we are most particular, as, failing this, in self-acting musical instruments all else is labour in vain); absolute steadiness and ease of discharge, by which perfection is obtained in the music or changes, or whatever work the machinery is called upon to perform; rapidity of lift, by which multiplicity of hammers is avoided and weight saved; ease with which repair can be done to any one given part without disturbing the machine as a whole; and last, but not least, cheapness, not the cheapness which is obtained by inferiority of workmanship, but cheapness which is obtained by simplicity of action—not using three actions where one will do, because our ancestors did it that way three hundred years ago, and therefore it must be right—and, consequently, saving material and labour, which make the cost.

DISCUSSION.

After a few words from Mr. Botly,

Mr. Ward said he doubted of the good effect of perpetually recurring chimes in a city, where they were disturbing rather than pleasant.

Mr. Hale then made a few observations.

Mr. John Lund remarked that, although he had but very few remarks to make, standing as he did in the relation of a brother to the reader of the paper, he could not help bearing his testimony to the patience and skill his brother had shown during the whole of the long and weary time he had spent over this machine. It had given him many sleepless nights and many a long day of anxious care, to produce the machine that stood before them. He could testify to the simplicity of the machine and to the remarkable results he was able to produce from it. As to the recording instrument at Greenwich, whatever might be the accumulated errors of the instrument, it could never interfere with the

little black spot which recorded what the error was. He felt there was only one more great step to perfect the machine, and that was the application of electricity to the discharge, which would leave the machine nothing else to do but the lifting, the discharge always being given by electricity. The machine might be reduced very largely indeed then, and put up in one corner of the room, where the bells themselves were played.

Mr. Ellis A. Davidson asked the opinion of the writer of the paper as to the effect of an inscription on the bells. It would be clear that the horizontal section of the bell would be a circle at the plain parts, but materially altered at the part where the inscription was. He desired to know whether a hemispherical bell, in its pure and simple form, would give a sound more power than it would if it were embossed at unequal parts by unequal projections. If the name of Lund, for instance, were put on the bell in a three-inch letter, and a quarter inch high, then, if he took a horizontal section, that section would not be a perfect circle, as at other parts. Would that interfere with the sound?

Mr. Lund replied that he really did not pretend to understand the scientific part of the question. He, however, knew that the name of the founders was generally inscribed all round the bell, and the note was produced quite perfectly.

The Chairman said it became his duty to ask those present to join him in a vote of thanks to Mr. Lund for the very interesting paper he had read. He thought it would be apparent to all that it had been a labour of love to him, and that he had brought to the subject a great amount of patient labour, attention, and scientific skill. As to the last paragraph, they must have all felt the soothing influence produced by a chime of bells, and many were the sweet recollections the village bells recalled to most of us. He agreed with the speaker who remarked that some bells in London were felt to be a nuisance, but even in London many people liked to hear a chime of bells. As to young beginners, he thought they would be deterred from commencing the study of change-ringing by the description of Mr. Lund. He would say, even if he had an inclination at his time of life to commence a new study, what had been stated was more than sufficient to deter him, and he would rather prefer commencing the study of Hebrew or Sanscrit. He asked them to join with him in sincerely thanking Mr. Lund for his paper, and in congratulating him, after the years of labour he had bestowed, on the satisfactory results he had produced. He could only express a hope that those labours and the intelligence he had shown might not cease, but that they might be devoted to some other work in the same branch, which might tend to be useful to both science and art.

Mr. Lund, in reply, said: I rise to thank you, ladies and gentlemen, for the kind way in which you received my paper. I can assure you it has been a very great pleasure to me to come here and read it.

The vote of thanks was then passed.

A skull - watch which once belonged to Mary, Queen of Scots, who had numerous watches if tradition may be believed, is in existence. Upon it the arms of France and Scotland are engraved in separate shields on each side of the jaws. An inscription—"Ex dono Fr. R. Fr. ad. Mariam Reg. Scotorvm et Fr.," together with the date 1560, shows that Francis II. of France, presented it to his young wife many years before watches were supposed to have been brought to England from Germany.

About the year 1696, Burdeau, a clever mathematician, constructed a remarkable clock in compliment to Louis XIV., whom in this ingenious work he highly flattered. On a rich throne, surrounded by all the pomp of royalty, was seated "le Grand Monarque;" around him stood the Electors of the German States, and the princes and dukes of Italy. These advanced towards the king, and, after doing homage, on retiring chimed the quarters of the hour with their canes. For the kings of Europe was reserved the more dignified office of striking the hours, after having paid their respects to the king. This piece of automaton clockwork was very gratifying to the French people of the time of Louis XIV.; and many who admired it persuaded the maker to exhibit it publicly. Unfortunately for Burdeau, he advertised his intentions to do so in the newspapers, and attempted too much in order to gratify the great crowd of people which collected in consequence. Knowing the stubborn and unyielding will of William III. of England toward his sovereign, the artist determined to make William's effigy more pliant, so that when its durn came, it should make a very humble obeisance to Louis. William, thus compelled, bowed very low indeed; but at the same instant some part of the machinery snapped assunder, and threw "le grand Monarque" prostrate from his chair at the feet of the British king. The news of the accident spread in every direction as an omen; the king was informed of it, and poor Burdeau was confined in the Bastile.

EFFECT OF THE MOON ON THE WEATHER.

(From the "Smithsonian Report.")

Since the form of the orbit of the earth is affected by the attraction of Venus and the other planets, as well as by our satellite the moon, they must in some degree also affect the form of the atmospheric covering of the globe, and tend to produce tides which are of greatest magnitude when they are in opposition or conjunction with the sun; but whether these disturbances of the atmosphere or those produced by the moon are of such a character as to give rise to the violent atmospheric commotions, denominated storms, is a question which has long agitated the scientific world.

The times and peculiarities of the meteorological occurrences are more varied and less definitely remembered than almost any other natural phenomena, and hence the large number of different rules for predicting the changes of the weather. The only way of accurately ascertaining the truth of any hypothesis in regard to atmospheric changes, is that of having recourse to trustworthy records of the weather through a long series of years, and it is one of our objects in collecting meteorological statistics at the Smithsonian Institution to obtain the means of proving or disproving propositions of the character you have advanced.

The moon, being the nearest body to the earth, produces the highest tide in the waters of the ocean, and must also produce the greater effect on the aerial covering of the earth. It has, however, not been satisfactorily proved that the occurrence of the lunar tides is connected with appreciable changes in the barometrical or thermometrical condition of the atmosphere. The less pressure of the air, at a given place, on account of the action of the moon, is just balanced by the increased height of the aerial column.

The principal causes of the violent changes of the atmosphere are, I think, due to its instability produced by the formation and condensation of vapor. It is not impossible, however, that when the air is in a very unstable condition on account of the heat and moisture of the lower strata, that the aerial tide may induce an overturning of the tottering equilibrium at some one place in the northern or southern hemisphere more unstable than the others, and thus commence a storm which, but for this extraneous cause, would not have happened. To detect, therefore, the influence of the moon, it will be necessary to compare simultaneously the records of the weather from day to day throughout all the northern and southern temperate zones, and to ascertain whether the maximum of these changes have any fixed relation in time to the changes of the moon. The fact that the problem has not been considered from this point of view, may account for the failure, in the study of a series of records at a single place, to furnish evidence of the action of the moon.

The changes of the moon take place at a given moment on every part of the earth; the greatest effect of a lunar tide ought, therefore, to be felt in succession entirely around the earth in the course of about twenty-four and one-half hours.

The problem, however, has not been solved and cannot be determined by such casual observations as those which you narrate. I have not the least idea that the attraction of Venus produces any appreciable effect. It is too small to produce a result which would be indicated by any of our meteorological instruments.

Sir Richard Phillips tells us in his "Chronology" that in 1787, a shark was taken in the Thames near Poplar, and in its belly was found a watch, with the name of Watson engraved upon it. It belonged to a young gentleman who had been drowned near Falmouth.

In 1785 died Peter Roy, who was watchmaker to the King of France. He was the author of the Memoirs for the Clockmakers of Paris, entitled "Etrennes Chronometriques." Julien le Roy, a relation of this mechanician, was a famous French watchmaker, of whose reputation his brother artists in Paris were jealous, and they did what they could to imitate him. J. B. Baillon, the queen's horologer, tried to outdo him, and he made all sorts of whimsical clocks and watches, adding toys to them as the fashions of the court required change. This man died young, and probably the richest clock and watchmaker in Europe.

In the palace of Versailles, in the Salon du Conseil, is a curious clock, that plays a chime when the hour strikes, and is set in motion by machinery, by which also sentinels are made to advance, a cock to flap his wings, Louis XIV to come forward, and a figure of Victory or Fame to descend from the skies and crown him with a golden chaplet. The Salle des Pendules in this palace is so called from a clock in it, which shows the days of the month, the phases of the moon, the revolutions of the earth, and the motions of the planets, besides the hour, the minute, and the second of the day. We may here mention incidentally that French clock cases were formerly accounted the first in the world, and those made by Boule in the time of Louis XIV. are looked upon as curiosities of good taste and workmanship.

etters to the Editor.

to be addressed to the Editor, at the .ute, 35, Northampton Square, E.C.

'ditor of the HOROLOGICAL JOURNAL.

Happening to look over the Green- for 1870, I observed the balance of nometer standing highest was not as "without axuiliary," which was no cause of the "little mistake" in arision of rates of chronometers in *rnal* for April, pointed out by Mr. in the last number. I recollect ch pleasure that Mr. Knudsen, in mbers, favoured the readers of the with his valuable experience, and he will supplement his short ex- in the May number with some marks on the subject.

Yours, &c.,

J. M. D.

'here are several errors in my paper ver Escapement in the *Journal* for

29, col. 2, line 10 from bottom, 30° 30′; line 11, for "rim" read 'age 130, col. 2, for "working" read " and in formulœ in same column, read $\frac{a-b}{a+b}$. This error also occurs 131, and on same page, $\frac{2}{C}$ should be 30, col. 1, line 9 from top, for second secant," page 132, col. 2, for, from obtain log

d from page 131 we obtain log $\frac{a-b}{a+b}$ × is used in several places instead is,) but the figures are correct

JOHN FEWTRELL.

gham.

all be glad to have Mr. Fewtrell's order to send him proofs of future ation.]

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n reply to "Tempus," I had an clock to repair, over twenty years a snail like the diagram he has given. ould, however, be another notch at a to make the long step into three , we should then have twelve steps common snail.

cking detant had two arms with hooked ends, and a spiral spring round the arbor which kept the one arm pressed against the snail steps; the other arm was then in a position to catch the pins in the locking wheel. In the side of the locking wheel was a number of concentric circles corresponding to the steps in the snail, and upon which the locking pins were fixed.

The action of the striking was this:—"Let us suppose it is one o'clock, one arm resting against the highest step of the snail, on the left hand side of the deep notch; and the other on the innermost circle, with a pin locked against it, when the striking is let off by the lifting piece in the usual way, the detant arms will drop after the unlocking to the same position, and a second pin on the inner circle will lock against the arm, there being, of course, a sufficient interval between the pins to allow one blow of the hammer, then, at two o'clock, after the unlocking, the snail arm of detant will drop unto the second step, and the locking arm will be on the second circle of wheel, and will catch a pin on this circle when the hammer has struck two blows, and so on till six o'clock; after this, the snail arm is elevated a step each hour, and at twelve falls into the deep notch; but there must have been some contrivance for lifting the arm up the steps, and out of the twelve o'clock notch, but I have quite forgotten this part. It was, however, the most troublesome and useless affair I ever met with, and was called Davis's "Patent" lever clock. To take the striking part away from a clock of this sort would certainly be no sin, and I feel sure, "Tempus" will not be tempted to restore it.

JOHN FEWTRELL.

Birmingham.

SIR,—I hope the members of the Horological Institute will have many opportunities of inspecting together the large public and private works which are calculated to add so much to our knowledge of the many ways in which machinery is, and may be employed, in facilitating and saving hand labour. I had the pleasure of being one of the party of Horological visitors to the Royal Mint on the 12th May, and was much pleased and instructed with the beautiful and accurate machines employed in the manufacture of our coin. The last process, that of weighing the finished coin in that marvel of a little machine (invented by Collon) was particularly interesting; the machine delivering the half-sovereigns — it was half-sovereign day—into three separate boxes or compartments as quick as ene could count them: those that were too heavy, those that were correct weight or "medium," and

those that were light. I asked the attendant, who gave us all the explanations, what was the per centage of the coin that was rejected? and, after a few questions, ascertained that it was forty per cent., and sometimes more; or, in other words, that nearly one-half of this coin manufactured with so much care, with such an excellent system in guaging and weighing, had to be sent back to the melting pot on account of its imperfect weight. The conclusions I came to from this information were: first, that it cannot be more difficult to produce by machinery half-sovereigns of exactly corresponding weight than to produce the various parts of a watch to given sizes and shapes, even if we were agreed upon the exact sizes and shapes of the various parts of a watch, which at present makers are not. Second, that as we watchmakers are not likely to have a better system than that employed at the Royal Mint, no more accurate or expensive machinery—one pair of scales costing £500—that we are not likely to employ it in watch manufacturing with better results. Thinking the above facts might interest some of yours readers, I trouble you with this letter, and I beg to call the attention of those to it, who no doubt conscientiously believe the time at hand when we will be imitating the Americans in making watches exclusively by machinery. D. GLASGOW.

Visit to the Royal Mint.—Thirty of the members of the British Horological Institute paid a visit to the Royal Mint, on Tuesday, 12th May, by permission of the Deputy-Master, and were favoured by an explanation and inspection of the various operations embodied in the operation of coining. By a regulation of the Mint authorities, the members were divided into batches of six, the circuit of each party occupying about forty minutes. The workshops were models of orderly arrangement. The machinery for stamping out the blanks for half-sovereigns from the bars of gold previously rolled to the desired thickness, was especially noteworthy, the rapidly recurring motions exercising a facination on the beholder. Equally ingenious were the methods of turning up the edges and milling the coins. The attention of members was particularly directed to the method of forming the dies; a piece of soft steel, turned conical in shape, being forced with enormous pressure by hydraulic power against a hardened representation of the coin the die was required for. Perhaps the culmination of mechanical skill is exhibited in the exquisitely sensitive automatic arrangement in use for weighing the finished coins. Altogether the visit was most interesting.

SIDEREAL TIME OF THE SUN'S SE METER PASSING THE MERIDI GREENWICH, AND EQUATION O TABLE.—June, 1874.

Day of the Week.	Day of the Month	Sidereal time of the Semidiam passing the Meridian.*		Equation of Tim to be subt. from / added to Apparent Time.	
		S.	M.	M.	S.
Mon	1	1	8·41	2	30·05
Tues	2	1	8·46	2	20·97
Wed	3	1	8·51	2	11·50
Thurs ..	4	1	8·56	2	1·65
Fri	5	1	8·61	1	51·44
Sat	6	1	8·65	1	40·88
Sun	7	1	8·69	1	29·99
Mon	8	1	8·73	1	18·78
Tues	9	1	8·77	1	7·29
Wed	10	1	8·80	0	55·52
Thurs ..	11	1	8·83	0	43·50
Fri	12	1	8·86	0	31·25
Sat	13	1	8·88	0	18·80
Sun	14	1	8·90	0	6·19
Mon	15	1	8·92	0	6·57
Tues	16	1	8·94	0	19·44
Wed	17	1	8·95	0	32·39
Thurs ..	18	1	8.96	0	45·40
Fri	19	1	8·97	0	58·43
Sat	20	1	8·97	1	11·47
Sun	21	1	8·97	1	24·49
Mon	22	1	8·96	1	37·47
Tues	23	1	8·95	1	50·38
Wed	24	1	8·94	2	3·21
Thurs ..	25	1	8·93	2	15·92
Fri	26	1	8·91	2	28·51
Sat	27	1	8·89	2	40·94
Sun	28	1	8·87	2	53·20
Mon	29	1	8·84	3	5·27
Tues	30	1	8·81	3	17·13
Wed	31	1	8·77	3	28·77

* *Mean* Time of the Semidiameter may be found by subtracting 0^s·19 fi *Sidereal* time.

British Horological Ins

DIARY of MEETINGS for JUNE,

DAY.	DATE	TIME.	BUSINESS
Monday	1	8.0	Technical Class.
Tuesday	2	8.30	Council.
Thursday	4	8.0	Technical Class.
Monday	8	8.0	Ditto.
Thursday	11	8.0	Ditto.
Monday	15	8.0	Ditto.
Wednesday	17	8.0	Paper by W. G.
Thursday	18	8 0	Technical Class.
Monday	22	8.0	Ditto.
Thursday	25	8.0	Ditto.
Monday	29	8.0	Ditto.

British Horological Institute.

IMPROVEMENTS OF THE LEVER ESCAPEMENT.

aper read before the Members of the Institute, by Mr. W. G. SCHOOF, on Wednesday, June 17th, 1874.]

MR. JOHN JONES, F.R.G.S., Vice-President, presiding.

NE and pocket chronometers have been
ght to such perfection that it would
st seem impossible still further to im-
upon them. This, however, applies
strictly to marine chronometers, which
onstructed to perform always in the same
ion, being suspended on gimbals, and
fore they are not subject to errors arising
the different positions in which pocket
iometers have to perform. They are also
ubjected to violence and sudden changes
ition, such as watches have to undergo in
ary wear. On this account the spring-
it escapement, which answers so well
rine chronometers, has almost entirely
supplanted by the lever escapement in
hes. Nevertheless, the spring-detent
ement has its weaknesses, of which even
arine chronometers it would be well to
id, provided the same accuracy of per-
ance could be secured. The balance gets
pulse only every oscillation; that is, at
other vibration, whereby some amount
ce is lost in the drop which the escape-
must have when giving its impulse to
oller. This loss is much greater with
spring-detent and duplex escapements
with such escapements as the lever, with
the impulse is given at every vibra-
So much is this the case that, other
s being alike, a larger arc of vibration can
tained with the latter than with the
r escapements. The unlocking action
the balance has to perform in connec-
with the spring-detent escapement is
resistant than with a well-made lever
ement, as it not only has to displace the
g pallet but also to bend the spring.
e, if a larger arc of vibration, or a heavier
ce, was not desirable, a weaker main-
might be substituted, which, besides
less liable to break and set, also reduces
iction on the pivots and acting surfaces
neral. The advantage of this decrease
ction might not be shown in a short
such as chronometers have to undergo
competitive trial at Greenwich Obser-
r, but would undoubtedly be shown in a
ness of rate during long intervals, because a gradual increase of friction, arising from the wear of the pivots thickening the oil, is one of the causes, although not the only one, which alter the rate.

Another disadvantage of the spring-detent escapement is its liability to trip when the timepiece is rotated so as to increase considerably the arc of vibration of the balance. On the contrary, the same rotary motion may cause the timepiece to stop, or set, if it should happen to be against the vibration of the balance, instead of with it. These remarks apply, of course, with much greater force to the pocket chronometer with the spring-detent escapement than to the marine chronometer with the same escapement, on account of the much greater care which is taken with the latter.

It may be here remarked that the chronometer escapement as used at the present day is the same, or nearly so, as perfected by its inventors, Earnshaw and Arnold; whereas the lever escapement has undergone a long series of modifications, whereby it has now attained a degree of perfection which fairly entitles it to be considered a sounder and better escapement than the spring-detent. Indeed, the lever escapement has almost entirely superseded the spring-detent for pocket chronometers, and it is submitted that its use in marine chronometers would be attended with as good results. There really seems to have been but one objection advanced against the use of the lever by some chronometer makers, and that is the necessity for oil on the pallets, although other makers consider this objection altogether absurd, while others again maintain that on a short angled* pallet oil may be dispensed with, even with a brass or steel escape-wheel. Neither on the verge of the verge watch nor in the notch of the lever, nor on the upright teeth of the escape-wheel of the duplex, nor on the teeth with the spring-detent escapement is any oil applied, it being considered rather hurtful than beneficial. It has, however, been found that

* A short angled pallet is one that will give an angular motion of from 8 to 10 degrees to the lever.

with a brass escape-wheel the vibrations will after a time fall off if no oil is applied to the wheel teeth, although it appears, thanks to the properties of the balance spring, that the duration of the vibrations remains the same; but with a large angled pallet the decrease in the arc of vibration will be much greater than with a short angled one. Still, as oil is found necessary with the wheel as usually made, it is submitted that the oil may be dispensed with by using a ruby short angled pallet and an escape-wheel with gold teeth, or, perhaps, the points only of gold. Such a wheel might be made in a similar manner to that by which the blanks for compensation balances are made, by melting gold around the edge of a disc of steel, or by soldering a ring of gold around the disc, from which blank the wheel would be cut in the usual way. The advantage of using steel, instead of gold entirely, is that greater strength and lightness would be secured. If we inquire into the reason why oil should be given on the wheel pallet of the lever escapement, and omitted on the impulse pallet or roller in the spring-detent escapement, the answer must be that it is on account of the opposite direction in which the short pallet of the lever escapement is impelled to the motion of the escape-wheel; and, if it were practically possible, the long pallet which is impelled in the same direction as the escape-wheel might be left without lubrication. In fact, the short pallet's motion is a slide with a thrust, whereas the long pallet's is a slide with a drag.

It may be further laid down that the necessity for lubrication on the short pallet is 1, in proportion to the pressure which the tooth exerts on any given poiut of the pallet; 2, that the greater the perpendicular height through which the pallet has to be lifted, the greater is the pressure on any given point; 3, that the stronger the pressure on any given point, the thicker ought the oil to be which is used as a lubricator; 4, the less the number of teeth that the pallet escapes over, the shorter is the perpendicular height through which the wheel pallet has to be moved in order to produce the required number of degrees of impulse.

The smallest number of teeth which we can make a pallet escape over to a 15 tooth wheel is three, unless we make the wheel reach beyond the pallet arbor; but with an escape-wheel of 10 teeth and a pallet escaping over two teeth, we decrease the perpendicular height by one-sixth, or nearly 17 per cent., so that the pressure at any given point is less in the same proportion.

The driving plane on the short pallet of ten degrees would, with a pallet over three teeth and a fifteen tooth wheel, point to about the middle of the opposite driving plane; but, with a wheel of ten and pallet escaping over two teeth and the same angle of impulse, namely, ten degrees, the driving plane would point considerably above the locking corner of its opposite pallet, so that it would be equivalent in the lightness of its action, or in the pressure on any given point, to a five or six degree pallet of the other combination.

But an escape pinion of fewer teeth or leaves, and a fourth wheel with a greater number of teeth, would, of course, be necessary in order to have the fourth wheel travelling once round in a minute, or showing correct seconds; but this cannot be a drawback, as it lessens the pressure on the locking planes in the same proportion as it lessens the pressure on the impulse planes. In the marine chronometer, on the table, the usual escape pinion of ten has been supplanted by one of eight leaves, and the usual fourth wheel of 80 by one of 96 teeth; which gives, with the ten toothed escape-wheel, the usual number of 14,400 vibrations per hour, or 240 per minute, and each beat is a quarter of a second of time.

In the watch here shown the usual wheel and pallet is used, but in connection with improvements in the lever and roller and resilient actions which shall be described presently.

The improvements in the lever escapement now to be described give it still greater advantages over the spring-detent. In the first place, the escape-wheel is planted in a straight line between the pallet and the balance staff, so that the arbor of the escape pinion passes through a hole, or slot, cut in the lever and large enough to free the pinion arbor when in action; thereby securing two advantages over the so-called right-angled lever, or escapement planted so that the centres of the wheel, pallet, and balance staff form a right-angled triangle; firstly, the power of the escape-wheel is given on the same side of the pallet pivot as it is transmitted to the balance, thereby securing for the escapement a similar advantage to that which the reversed fusee gives to the train; secondly, the lever and pallet, forming a cross, can be poised so as not to cause the error in positions which arises from unpoised lever and pallet. The poised lever would not be required for a marine chronometer, because it is always kept in the same position, and, of course, it would be most important in high class watches.

In the next place, the escape-wheel is made of steel, but with gold teeth, so as to lessen the weight of the wheel and diminish the friction on the pallet.

Further, the escape-wheel is made with 10

eeth only, and the pallet embraces a space and a half, instead of the usual wheel of fifteen teeth with pallet escaping over two and a half spaces. This shortens the distance which the wheel has to lift the pallet in order to get the same usual angular motion of the lever. The mode of escaping, the material of the teeth, and the position of the wheel, conjointly conduce to lessen the necessity for oil on the pallets, if not entirely to remove it.

As the improvements in the lever and roller action, now to be referred to, have the same objects, or purposes, as the so-called two pin escapement, invented by George Savage, it may be stated that his invention was intended to separate the unlocking action from the impulse action, and, at the same time, to perform both as nearly as possible in the line of centres of the roller and the lever, whereby friction is considerably diminished; also to perform the unlocking action nearer to the centre of the roller than in the ordinary lever escapement where one ruby pin does for both; thereby an easier unlocking action is secured.

He attained these objects to a limited extent only, because it was found by experience that unless the notch in the roller was made much wider than was otherwise necessary, the impulse pin in the lever would, under certain contingencies, such as an extra rotary motion being given to the balance by the wearer, abut against the opposite side of the notch and so interfere with the continuous free vibrations of the balance. The unlocking pins, or jewel, had therefore to be put much farther from the centre than was originally intended, so much so that in this escapement, as made at the present day, the unlocking pin, or jewel, is set as near to the edge of the roller as it can possibly be, thereby giving up the intended advantage of easier unlocking. Nevertheless, all these advantages, aimed at by Savage, can be secured even to a greater extent by improved arrangement. Instead of having a notch cut in the edge of the roller, and a single pin in the lever acting on each side of the notch alternately, a jewel may be planted in the middle of a small crescent in the edge of the roller, and this impulse pin, or pallet, can be allowed to perform the last fractional part of the unlocking action by engaging with two upright pins or pallets fixed on the lever, which act both as impulse and guard pins. This arrangement does away with any possibility of the aforesaid abutting, and allows the unlocking action to be performed by a ruby pin put very near to the centre of the roller, whereby an easier unlocking action is secured.

This construction of the lever escapement gives facilities for the application of mechanism for preventing the possibility of banking error, which in ordinary escapements is caused by the striking of the impulse pin against the lever after having traversed a full turn in one direction, from its position of rest, without having finished its motion; which mechanism is of great importance in high class watches in which a large vibration, thin pivots, and a heavy balance are necessary.

The specialities of these improvements, as respects the resilient action, will now be stated. Perhaps the best of the modes by which this is proposed to be obtained is the one in which a separate yielding banking piece is placed in such a position as the construction of the watch conveniently allows. It consists of a flat piece of steel, carrying the two banking pins and centered on an axis which allows it to move freely, and held in position by a spring close to the axis. Under ordinary circumstances this acts the part of the usual rigid banking. When, however, the balance performs an abnormally large arc the unlocking pin, striking the back of the prongs of the lever, causes the lever to press upon the banking; and this force, acting upon the detaining spring, causes it to yield so as to permit the unlocking pin to pass, instead of rebounding, as in the ordinary lever watch. This plan does not add to the weight of the lever, being altogether detached.

Perhaps the simplest mode of obtaining the resilience is the one in which the mechanism is formed upon the lever itself, using rigid banking pins. A long spring, bent double, is fastened at the bend in a stud on the tail of the lever, and rests with its free ends in the prongs of the lever, the ends being left broad enough to go into the prongs. The fork of the lever is here formed for the mere purpose of holding the spring in position. The ends of the spring protrude far enough to serve the purpose of the fork in the lever used in the arrangement previously described. The action is as follows: under the ordinary going of the watch the unlocking pin acts on the inner side of the spring, which is held rigid, against a force on this side, by the fork of the lever. When the balance, however, receives an abnormal vibration the unlocking pin strikes against the outer side of the spring which allows it to pass onward, being yielding to force on that side; thereby preventing the so-called banking error, and also the bending of the balance pivots and breaking of the ruby pin, which sometimes result from too violent banking.

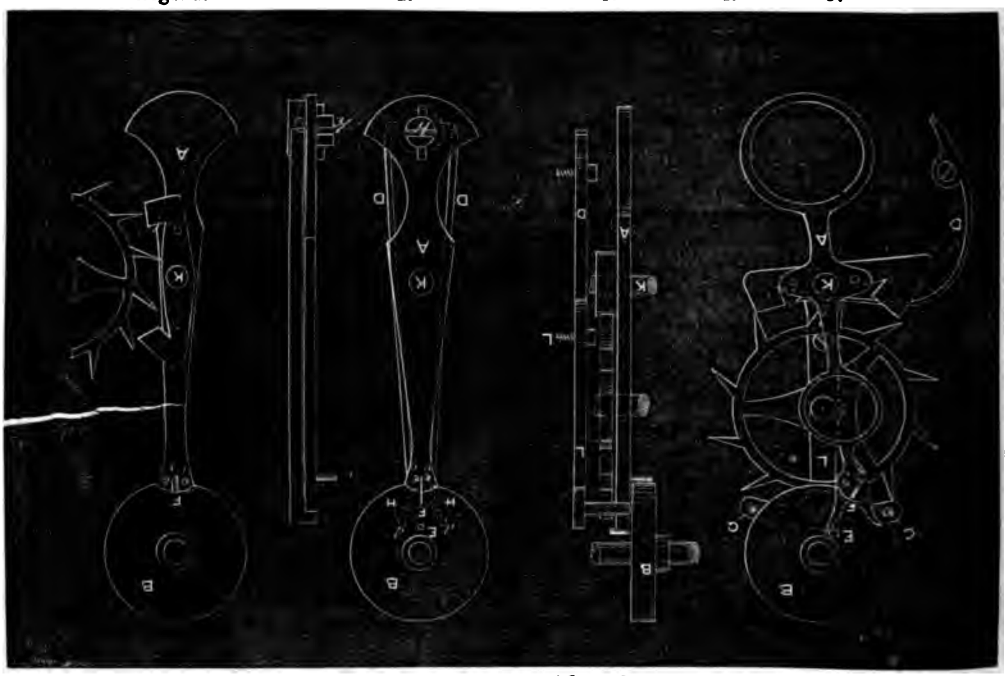
The details of these improvements are represented in Fig. 1 to 5, in which A represents the lever; B the roller; G G the banking pins; D the resilient spring; F the im-

pulse pin in the edge of the roller; C C the vertical pins in the lever; H H the prongs of the lever; K the fulcrum of the lever.

In Fig. 1, G G L is the yielding banking-piece, mounted freely on the axis L, but kept in position by the controlling spring D, and carrying the banking pins G G. Fig. 2 is a side view of Fig. 1. Fig. 3 shows the resilient spring D *d*, planted edgewise on the lever by the stud k, and held in position by the prongs H H, so as to form the unlocking surfaces *d d*, on which the unlocking pin E acts. Fig. 4 is a side view of the lever and spring in Fig. 3. Fig. 5 represents the simplest form of escapement in which the pin E acts both as unlocking pin and as receiver of the impulse; thus making it very similar in its action to the lever and roller as commonly made, but with this difference, that, the impulse being given at the outer circle of the roller, it admits of a sounder safety action, so much so that the expensive double-roller escapement is rendered quite unnecessary. The same remark, of course, applies to Figs. 1 and 3.

To show more in detail the advantages which are obtained by these improvements over other forms of escapements, it will be necessary to compare them with the forms of the lever escapement which most closely resemble them. To begin with Fig. 5, it will be proper to compare it both with the ordinary lever and with the double-roller escapements. In the former the unlocking and impulse actions are performed by a ruby pin placed *inside* the edge of the roller, so as to have

Figs. 1. 2. 3. 4. 5.



sufficient depth of crescent to allow the guard pin of the lever to pass, which makes the unlocking circle considerably smaller than the guard circle; and a longer run on the banking to free the guard pin from the edge of the roller when the lever is at rest against the banking is the result. In order to lessen the run on the banking and to maintain sound safety action, with a short angled pallet, the double-roller escapement was invented. In this form of escapement a second smaller roller is placed on the balance staff, and a stud is screwed on the lever long enough to act as guard pin against this smaller roller. By these means a sounder banking and a larger vibration of the balance are obtained; but considerably more work and greater skill are required to make this escapement. In the escapement represented by Fig. 5 the impulse pin stands as much *outside* the circumference, which represents the safety circle, as the ruby pin must be planted inside the same circle in the ordinary roller; and, although the distance of each of the two upright pins from the centre line of the lever must be deducted from the distance the ruby pin is inside the roller, in order to compare the closeness of escaping, the lever and roller, as in Fig. 5, can be escaped as close as the double roller and will give, all other things being similar, the same amount of vibration to the balance with perfect safety action; because the impulse pin engages the

two upright pins in the lever long enough to bring them alternately in contact with the roller just outside the crescent, under such conditions as make the safety action necessary.

Fig. 5, as well as Fig. 1, of course, may be made with or without resilient action, which would perhaps only be necessary in high class work; but the ordinary banking must be used when resilience is omitted. Without the resilient, or yielding, banking piece Fig. 1 would most nearly resemble the two pin escapement of Savage. It has, however, considerable advantage over the latter.

The prongs of the lever can be made nearly to reach the balance staff, but they should be carefully made the right distance apart and in the direction as shown in the drawing, in order to give the unlocking pin as much of the unlocking action to do as possible. For this purpose the impulse pallet in the edge of the roller should be made thin, and the chord of the crescent should measure nearly twice the distance of the pins apart, including their diameters. These pins should be made as thin as the usual guard pin is made; and, if short and of hardened steel, they will be very strong and not likely to be bent.

The acting lengths of lever and roller should be made sufficient to give an impulse of about 35 degrees to the balance, which with a lever motion of 10 degrees nett would be as three and a half to one.

These conditions are not absolutely necessary for ordinary good action; but with them the best possible vibration is obtained, amounting to from 25 to 30 per cent. more than can be obtained with the two pin escapement, all other things being alike, or similar; on account of its more favourable leverage giving easier unlocking and less loss from drop in the notch than in the two pin escapement.

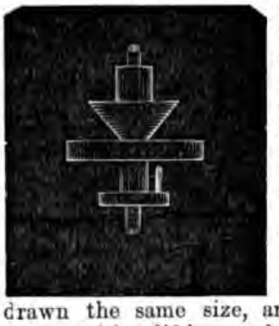
The yielding banking can be added in three-quarter plate watches underneath the dial, over and on the plate which contains the pivot-holes of the escapement. This plate should be made thin enough to allow room for a thin piece of steel between it and the dial.

The ordinary banking pins should be placed in small holes, as near the balance-holes as convenient; and, when correctly placed, corresponding holes should be drilled in the piece of steel which has previously been screwed firm in position underneath the dial. The screw or fulcrum, on which this banking piece moves, should be placed as far away from the banking pins as the space in the movement will permit, and as close as possible to the other end of the banking piece, which is here hollowed out in the edge to engage with a spring, placed in proper position round the inside edge of the watch movement. In full-plate watches and marine chronometers there will be plenty of room underneath the upper plate for this purpose. It may here be stated how a safe resilient action, free from abutting, should be secured. The resilient, or yielding banking piece, should not be allowed to yield farther than just necessary for the unlocking pin or pallet to pass, which may be done, either by a pin placed on each side of the banking piece, or by allowing the opposite ends of the banking pins just room enough in the plate for that purpose. The prongs of the lever should be formed into a point on the extreme ends, so that should the unlocking pin come to rest on the top of the lever prongs it can slip off on either side. The same holds good with the resilient action obtained by Fig. 3.

By comparing these resilient actions with such as are obtained by the escape-wheel holding the lever, or by the tail of the lever being formed into a spring without any other support, it will be seen that any extra jerk given to the watch will cause much less vibration or tremor on the lever, as it is supported at the end opposite to that on which support is given by these resilient escapements. There is no necessity for unusual freedom between impulse pallet and the notch formed by the two upright pins on the lever, and the ordinary inexpensive wheel and pallet may be used, so that a common lever watch can easily be converted into a resilient lever.

As the improved pallet and wheel action have already been spoken of, in the beginning of this paper, it will only be necessary to mention that Fig. 1 represents the wheel with ten teeth and pallet escaped over one and a half spaces, and Fig. 5 the ordinary fifteen toothed wheel with pallet escaping over two and a half spaces. Both wheels are drawn the same size, and both pallets are drawn with a lifting angle of 10 degrees, so as to make the two comparable, and showing the diminished distance. Fig. 1 wheel pallet has to be moved for the same degrees of motion.

Fig. 6.



For small watches a roller and impulse pallet of the same piece, or an extra smaller roller carrying the unlocking pin or pallet, would be advisable, as the roller pallet otherwise would not have the necessary depth of hold in the roller; such a roller is represented in Fig. 6, and, if preferred, the small roller may be used as a safety-roller.

DISCUSSION.

The CHAIRMAN said it was impossible to over-estimate the importance of the subject which Mr. Schoof had opened. The improvement of watches was a matter the whole world was interested in. While many endeavoured to cheapen the production of watches, there were men in Clerkenwell who had earnestly turned their attention to the necessity of perfecting watches as timekeepers; and, from his carefully-prepared paper, it was evident that Mr. Schoof had in view the advancement of that end. The eminent men in that room, makers of the highest class work, would, no doubt, have some remarks to make upon what, perhaps, he might venture to call the rather startling propositions of Mr. Schoof, who, he had no doubt, would be well able to defend his ground. He (the chairman) would suggest that they should take the classification adopted in the paper. There was, firstly, the rather jeopardising thought that oil might be dispensed with by using the pallet wheel teeth tipped with gold, and adopting the adventurous idea of discarding the fifteen toothed escape-wheel in favour of one having ten teeth and escaping over a less number. Upon that point he should like to hear the opinion of the makers present, and afterwards they could consider the value of the unlocking nearer to the centre, and the other propositions made by Mr. Schoof.

Mr. TILLING said he had over and over again tried escapements without oil in instances where the teeth of the escape-wheel were of gold, but the result was always unsatisfactory, no matter how many teeth were 'scaped over. He thought it would be unwise to alter the number of teeth in the escape wheel from the universal fifteen. Mr. Schoof's arrangement was not original, he himself had described something similar in a competitive essay he had written some time ago for the Institute, as Mr. Walsh could verify. No doubt the escapement of Mudge was perfect in principle. They had simplified some of the details with advantage, but Mr. Schoof's proposal to unlock so near the centre was a departure from the principle of Mudge that would not give good results. The guard pin not being small was also a weak point.

Mr. BARNARD considered gold wheels, which he had tried of various alloys, worse than brass, and even preferred steel wheels, which would go longer without oil.

Mr. WALSH said that steel and stone would certainly generate rust. One point in connection with the unlocking pin near the centre was that the unlocking was performed gently instead of with a percussive force. He thought, if the drawing were correct, there would be a liability of the impulse pin to catch.

Mr. ISAAC had found brass wheels to answer better than gold for pocket chronometers. Mr. Schoof was probably aware that the late Charles Frodsham tried many experiments with escape-wheels having various numbers of teeth. It was easy to cavil with details. Of course long trials were necessary to solve the matter, but he thought great credit was due to Mr. Schoof, who, he hoped, would reap a golden harvest to compensate him for the pains he had taken.

Mr. SCHOOF said that from a daily practice of thirty years he could speak confidently of the value of gold as a material for rubbing surfaces, not only for wheels but for stoppings. Of course some alloys might not answer.

In answer to Mr. TILLING's remark that with the unlocking pin near the centre of the roller no good results could be obtained, the error of that remark could easily be proved by allowing the balance to vibrate without the balance spring, and was also refuted by the increased vibration obtained with his (Mr. Schoof's) lever and roller action. For that purpose the unlocking action could be performed by the pin or pallet in the edge of the roller. Such an arrangement is represented by Fig. 5.

In answer to Mr. WALSH, the part of the safety action which is obtained by the *root* of the horns against the ruby pin in the ordinary lever might with advantage be imitated in his escapement against a projection on the smaller roller already spoken of. The other part of the safety action against the circumference of the larger roller was more perfect than in any other known form of lever escapement.

The CHAIRMAN, in moving that the thanks of the members be accorded to Mr. Schoof, said it required an amount of courage to come before a body of men, especially watchmakers, to tell them that they had been holding erroneous ideas all their lives, and watchmakers were particularly hard to convince of the merits of anything new.

Mr. GLASGOW said even if every point advanced by Mr. Schoof were an error they were deeply indebted to him for coming there that evening and reading his carefully-prepared paper. The great want of their trade was men who would think at all, and it was only by perfecting every detail so as to produce the finest watches that England could hope to maintain her position in the markets of the world. He cordially seconded the vote of thanks.

The vote of thanks, having been carried, was acknowledged by Mr. SCHOOF, and the proceedings terminated.

THE HIGHER HOROLOGICAL ART.

RULES FOR THE CONSTRUCTION OF ASTRONOMICAL, NAUTICAL, AND OTHER EXACT TIME MEASURERS.

(BY URBAN JURGENSEN.)

(*Continued from Page* 138.)

OF THE RESISTANCE OF THE AIR TO THE COMPENSATION BALANCE.

THE resistance of the air is much greater to the compensation than to the ordinary balance, the compensation balance having usually a higher velocity and a much greater extent of surface than the balances which are found in ordinary timekeepers. This resistance is particularly remarkable in marine chronometers through the large diameter of the balance; as we shall see later, from the experiments which I have made in this matter, it diminishes the oscillations so much that in order to make them sufficiently extensive, it is necessary to increase the motive force in proportion, as the balance is affected by the air. But we are not in a position to reduce this resistance of the air to the lowest possible degree, neither by giving the balance a small diameter, nor by lessening its velocity for in both cases a real advantage would be sacrificed, in order to overcome a much smaller evil, as has been before remarked in treating of the resistance of the air to the balances of ordinary watches. All that we can do is to reduce, as much as possible, the surfaces which suffer resistance, and make them of such shape as is best adapted for cutting through the air.

One diminishes the size of the compensating and regulating weights, and by consequence, the resistance of the air, by employing a metal of greater specific gravity, such as gold or platinum, which is in this respect better. If we give the compensating weights the shape shown in Fig. 23, p. 138, they will naturally cut through the air better than those which present broad and flat surfaces. As for the regulating screws, it is well to make the heads of a lenticular shape, like an ordinary pendulum bob, or, at least, to make them as little flat as possible, and round off the corners. In this way, the resistance of the air is very much decreased.

THE ISOCHRONISM OF THE OSCILLATIONS OF THE BALANCE, AND OF THE CYLINDRICAL BALANCE SPRING.

The arc of oscillation of the balance becomes constantly smaller the longer the watch goes, for the friction increases through the accumulation of dirt and the thickening of the oil, and thus prevents the wheel work from transmitting as much force to the balance, which itself experiences an additional resistance to its motion by the thickening of the oil at its pivots. The shaking which a watch is subjected to in carrying in the pocket, or a marine chronometer on board ship, affect more or less the extent of the oscillations of the balance.

This alteration in the extent of the oscillations is particularly injurious in those time measurers where the highest accuracy is sought for. Two talented men have in different ways overcome this difficulty, and have given us the means to cause a large oscillation of the balance to be performed in the same time, as a small one; in other words, to make the oscillations of the balance isochronal.*

The isochronism of the oscillations of the balance is the foundation of accuracy in marine chronometers. The two celebrated artists whom we have to thank for the discovery of isochronism accomplished their object in different ways.

Pierre le Roy's method, which is mostly followed, is founded upon the fact, that a very short balance spring which is of the same thickness throughout its whole length has, by the motion of the balance, its tension increased in much greater proportion than a long spring has. In consequenc of this, a large arc of oscillation is completed in less time than a small one. On the other hand, in a very long balance spring, with the arc of oscillation as before, the proportion of the tension is very much less, and in this case the larger oscillations are completed in longer time than the small ones. Between these two extreme lengths, there is a mean where the large and small oscillations are of equal duration. This is the theory, and by experience we find that in practice it is completely correct.

Ferdinand Berthoud's method of producing an isochronal balance spring is founded upon an entirely different principle to Pierre le Roy's, as he obtains isochronism by means of the form of the spring and not by its length.† Ferdinand Berthoud makes the spring propor-

* Pierre le Roy and Ferdinand Berthoud have given us the methods by which they were enabled to achieve a perfect isochronism by means of the balance spring.

† The above is hardly correct. Berthoud's method was graduating the thickness of the spring. Another inventor since the time of Jürgensen, Professor Phillips, of the School of Mines, of Paris, has proposed a method of obtaining isochronism by the *form* of the balance spring. *Vide* p. 13, vol VI., and p. 97, vol. XIV. of the *Horological Journal*.—GEORGE MAYER.

tionately thinner, *en fouet* (like the thong of a whip), as the distance increases from the middle point of the spring. By this means a shorter spring than that of Le Roy's may be made isochronal.

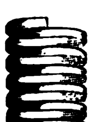
Either method may be usefully employed, but Le Roy's is used wherever possible, in consequence of the great advantage of requiring only a wire of the same thickness throughout its length. In watches the size and shape of which do not permit of a very long spring we may fall back upon Ferdinand Berthoud's method, but in carrying it out we are met with the very great difficulty of reducing the size of the spring in an exact and suitable proportion.

We shall further on resume this important subject of isochronism, and give the proportion which experience has shown to be the best, between the duration of the large and the small oscillations of the balance, because in practice it is found that in a chronometer, the rate of which should be the same for a long time together, it is well that the isochronism should not be theoretically perfect. This point can only be got at by trying, which, of course, necessitates that the chronometer should be finished and going, so that it cannot be treated of in this part of the work.

The shape of the balance spring in a marine chronometer is shown in Figs. 24 and 25, which, as is seen, is cylindrical.* The balance springs in chronometers are generally made either of gold or of steel. If steel is used it may be hardened either by the fire or by drawing. Most springs are not fire-hardened, but by cold drawing, and experience has shown that in this way, by means of compression of the particles of the metal, the spring obtains the necessary degree of hardness or elasticity. In hardening the spring by the fire there is a possibility of its becoming too brittle a thing; we need not fear when the wire is drawn hard. The art of making balance springs of steel is the easiest and quickest, because flat and hard-drawn wire of every size is readily procurable, though I use 16 to 18 carat gold for the balance springs which I make, and have every reason to be satisfied with this metal, for it has all the elasticity that could be wished for, although the making of a gold balance spring is a much longer and more troublesome operation than a steel one for which we have the wire ready made to hand. I have not been able to abandon a method which has proved so good, and which, besides, possesses this great advantage—that a gold spring is quite secure from rust, a thing which sooner or later is sure to attack a steel spring in a marine chronometer.* By trial with a suitable instrument, constructed for the purpose of determining the elasticity of balance springs, it has been found that those springs made of 18 carat gold (when the gold is alloyed with pure copper and drawn into wire in the usual way) retain their elasticity when submitted to a torsion of 360° and even more. This is not the case with springs of hard rolled steel, as has been proved by the following experiments:—Having taken a piece of round steel, as pure as possible, of one millimetre in thickness, this is passed through the draw plate, without annealing it, to convert it to a flat wire $\frac{1}{10}$ mm thick and $\frac{2}{10}$ mm broad. This wire was so hard that on bending it it almost broke like glass. From this a spring was made which was applied to a balance, but on subjecting this to a torsion of 360° the spring gave way more than one degree. This experiment was made several times with other hard-drawn wire, giving in every case nearly the same result. The same experiment was made with wires not drawn so hard, and the alteration was double, treble, and so on, according to the hardness; in steel quite soft the bending was much greater. Thus it is important that, to obtain a high degree of elasticity, the balance spring should be hardened and tempered. Eighteen carat gold, when it is alloyed with pure copper and drawn into wire, preserves its elasticity completely, and can therefore be used with advantage in marine chronometers, as it does not rust, but we must remember that a golden balance spring requires heavier compensating weights on the balance, in consequence of the greater expansibility of gold over steel.

Fig. 24.

Fig. 25.



* The balance spring which has the most elasticity and gives the greatest freedom to the motions of the balance is the spherical.

* With regard to the preference exhibited by many for a hardened steel spring over one that is not fire-hardened, or a gold one, I will here produce the testimony of Arnold, for the opinion of such a skilful and celebrated artist must have the greatest possible weight, and be an article of faith for all. He says: "The chronometer, No. 36, which was tried by the Astronomer Royal, 25 years since, had, and still has, the same spring of tempered steel. Mr. Edwards' chronometer, No. 68, had, and still, has the same spring of gold; and the marine chronometer, No. 82, had, and I believe still has, the same spring of hard rolled steel. *Experience is in favour of all three.* I think the gold and tempered steel will retain its identity longer than the other." Thus it appears that Arnold had equal success with springs of hardened and unhardened steel and of gold. Where all things are alike in regard to elasticity, it is clear that the preference should be given to the balance spring which is not liable to rust.

ABSTRACT OF THE REPORT OF THE ASTRONOMER ROYAL TO THE BOARD OF VISITORS OF THE ROYAL OBSERVATORY, GREENWICH.

[Read at the Annual Visitation of the Royal Observatory, 1874, June 6th.]

THE only alteration of any importance in the buildings surrounding the Front Court is the inclosure of the Mean Solar Standard Clock in the Ball Lobby within double sashes, with a view to reducing the alterations of temperature to which this clock is exposed.

The Transit-Circle is in good working order; it has not been found necessary to clean the object-glass since the practice was introduced of turning that end of the telescope downwards after observing.

The lenses of the object-glass of the North Collimator have been separated and cleaned.

Allusion was made in the last Report to a discordance between the results obtained for coincidence of the two Collimators in the two cases; first, when the instrument was raised so as to admit of a perfectly free view of one Collimator by the other; and, secondly, when a partial view was obtained through the pierced cube of the Transit-Circle. Since 1874, January 1, the Collimation Errors deduced from readings taken through the cube have been corrected by the quantity $+0^{r}\cdot019$ or $+0''\cdot28$; the effect of this correction on the resulting R.A.'s of stars is entirely differential, and therefore very slight.

A new determination of the ceofficient of flexure was made on 1873, May 30, agreeing well with the adopted value.

The recording-micrometer, referred to in the last Report, has been in regular use since 1873, June 20; some mistakes in reading off have been corrected by its means. By the help of this arrangement the system of making several bisections of an object in its passage through the field of view has been more fully carried out.

The arrangement for correction of the barometric inequality, to which I alluded last year, has been applied to the Sidereal Standard Clock with satisfactory results. The inequality is now considered reduced; but a further adjustment of the magnets is required for its complete correction, and this is necessarily a slow process, as a long series of observations is required to determine the effect of the barometer. A uniform acceleration of rate has been shown since the clock was brought into use again (after adaptation of the apparatus) on 1874, January 24, and this has somewhat masked the barometric inequality.

The clock Hardy, which was in a bad state, has been thoroughly renovated by Messrs. E. Dent & Co., the principal alterations being the substitution of new contact-apparatus and of a new escape-pinion for the old parts. While these repairs were being executed, the clock Arnold 1 was placed in the Transit-Circle-pit for use in observations of Circumpolar Stars, &c. The rate of this clock would probably be improved by the substitution of a zinc and steel pendulum (which has been found to answer so well in the Sidereal Standard and Transit of Venus clocks) for its old gridiron pendulum. This clock has now been fixed in the East Dome, where it takes the place of the clock Earnshaw, which has been lent to the Transit of Venus Expedition.

The Chronograph has worked satisfactorily throughout the past year, but will probably require cleaning before long. A pair of wires in connexion with the Chronograph is now carried to the Sheepshanks Equatoreal, and an additional pair to the Great Equatoreal.

The Altazimuth is in a very satisfactory state. The form of its pivots was ascertained by observation in 1873, May, when the apparent deviations from circularity were found to be well within the probable error of observation, so that no correction is required on this account. The instrument has been raised regularly each lunation about the time of New Moon, and the pivots cleaned and oiled. The new lifting-apparatus, which is provided with screw-jacks, is used for this purpose.

The Sheepshanks and Shuckburgh Equatoreals are in an efficient state for observation of occultations and other phenomena.

The Great Equatoreal is in excellent condition. Some trouble has been caused by the deposition of moisture between the lenses of its object-glass, which has been cleaned twice during the last winter. The quantity of water was too great to be expelled by a gentle heat, and it was eventually found necessary to separate the lenses on each occasion. Mr. Simms is engaged in making a light bridle-rod for more convenient setting in N.P.D. Fresh counterpoises have been attached to the instrument to balance the additional weight of the new Spectroscope, which was finally received from Mr. Browning's hands on May 2 of the present year.

The Spectroscope is specially adapted to sweeping round the Sun's limb, with a view to mapping out the prominences, and is available for work on Stars add Nebulæ, the dispersive power being very readily varied. An induction-coil, capable of giving a six-inch spark, has been made for this instrument by Mr. Browning; and various subsidiary apparatus has been procured.

The Reflex-Zenith-Tube is in an efficient state.

The Water-Telescope was dismounted in August last, the observations with it having been brought to a satisfactory termination.

The Ancient Instruments are in the same state as in former years.

The Kew Photoheliograph has been adjusted to focus, and brought into good working order. It has been used regularly since 1874, April, on every day on which the Sun could be seen; before that date the photographs for the regular series were taken with one of the photoheliographs constructed by Mr. Dallmeyer, under Mr. De La Rue's superintendence, for the Transit of Venus Expeditions. These instruments are an improved form of the Kew Heliograph, and were used by preference, until it became necessary to dismount and pack them for shipment.

The Moon on all days, and the Sun and large Planets on week-days, have been observed on the meridian whenever practicable; and great attention has been given as usual to the determination of all the instrumental errors. The observations of small Planets have been confined to the first half of each lunation, as in former years.

Some progress has been made with the observations of wide Circumpolar Stars; but, in view of the large number of stars included in our Working Catalogue, I have thought it desirable to limit the number of observations of each object to three measures of R.A. and N.P.D. above the Pole and three below. By this arrangement, it is hoped that the list will be cleared off in a few years; whilst accuracy will be attained sufficient for the object I had in view when this class of observations was introduced.

A few other stars have been observed, at the request of foreign astronomers; and, at the suggestion of Mr. Birmingham, the places of some of the stars of Schjellerup's list of Red stars were determined, and estimates of magnitude made. Though the determinations of brightness were necessarily somewhat rough, interesting changes in the light of one of these stars were fully established, thus confirming Mr. Birmingham's suspicions.

With the Altazimuth, the Moon and two stars for instrumental errors have been observed at every available opportunity; whenever haze or cloud prevented the observation of a Low Star, the Collimator was used.

Since the Spectroscope was received from Mr. Browning, the glimpses of the Sun which have been obtained have been to transient to admit of any systematic work on the solar prominences; but some progress has been made in determining the adjustments of the instrument.

A large number of protographs of the Sun have been taken since 1873, June 1, either with the Kew Photoheliograph or with one of the other instruments, and of these 266 have been selected for preservation, two photographs being usually reserved on every day of observation. Some of the negatives, for which the exposure has been but slight, exhibit the delicate mottlings on the Sun's surface in a remarkable manner; and it is proposed in future to take such photographs whenever practicable, besides those with a full exposure, which are more suitable for showing the details of spots. On two occasions a spot was photographed on the actual limb of the Sun, presenting the appearance of a notch partially filled up with less luminous matter.

There are at the present in the Chronometer Room 194 chronometers, which are regularly rated at least once a week. Of this number, 121 box-chronometers, 14 pocket-chronometers, and 19 deck-watches are the property of the Government, and are being rated after repair by the makers preparatory to their issue to ships of H. M. Navy and 40 belong to chronometer-makers, who have placed them here for the annual competitive trial. These latter are compared every day with the Mean Solar Standard Clock; and all the chronometers are, for one or more periods of three weeks each, tried in a temperature of nearly 100° Fahrenheit. Artificial cold has not been used for any chronometer. New chronometers are always tried in different positions with respect to the magnetic meridian.

During the past year three chronometers have been transferred to the War Office, for use in the Gold Coast Expedition, and have been replaced by three others, paid for by the War Office. The number of chronometers required for the Transit of Venus Expeditions is 46; and in view of such a large demand on the ordinary stock of Government chronometers, great exertions have been made to get the repairs of chronometers (returned from service) executed by the makers with as little delay as possible.

One chronometer has been transferred to the Eastney Royal Marine Artillery Barracks, and replaced by another purchased at the same price; three chronometers, intended for the Survey of Canada, have been tried for Mr. L. Russell.

The two chronometers at the head of the competitive list for 1873 had smaller trial numbers (representing the amount of unsteadiness of rate) than any chronometer in any previous year.

With the exception of eight days, on which the violence of the wind prevented the raising of the ball, and of two days on which accide-

al failures occurred, the Greenwich Time-Ball has been regularly dropped every day throughout the year to which this Report refers.

The Deal Time-Ball was not raised five days on account of high wind, and was not dropped on five days owing to interruption in the telegraphic communication. On one day, October 10, it was erroneously discharged four seconds before 1ʰ by a telegraphic signal; on 321 days it was dropped correctly by the current; and on 37 days, principally in rainy weather, the current was too weak to release the trigger without the assistance of the attendant's hand.

A proposal has been made to me to drop a ball at Portsmouth by direct current from the Royal Observatory, but no further action appears to have been taken in the matter by Admiralty.

Since the removal of the Telegraph Department from Telegraph Street, Lothbury, to the new building facing the General Post Office, a new and more elaborate chronopher has been constructed for the signal at 10ʰ A.M., in which provision is made for sending signals in sixty different directions, the old chronopher being still in use for the signal at 1ʰ P.M. Mr. H. Eaton, of the Post Office Telegraphs, has kindly furnished me with the following account of the distribution of signals :—

"The Greenwich current is received hourly. This hourly current is transmitted to 10 subscribers (mostly chronometer-makers) in London. The method of observing the current varies, and is fixed by the subscriber. In two cases, time-balls are dropped on the top of the buildings; in some other cases, model time-balls are placed in the windows; and others again use an electric bell; while two or three have a simple galvanometer, and observe from the deflexion of the needle.

"The Westminster clock records its correctness and errors at Greenwich, as does also the clock at Lombard Street Post Office.

"The 10 a.m. current is most extensively used for the Provinces. It is transmitted automatically to 21 provincial towns in England (where there are subscribers), to Guernsey, Edinburgh, Glasgow, and Belfast. In addition to the automatic sender, a sound signal is established in the Instrument Room here; when heard, a current is sent by the clerks to over 600 offices in direct communication with the Central Telegraph Office, including the principal railway termini. Many of these offices re-distribute the time-signal to the offices radiating from them, so that practically from the 10 a.m. current from Greenwich most of the post-office and railway clocks in the kingdom are regulated.

"The 1 p.m. current is transmitted automatically to nine provincial towns, viz., Newcastle, Sunderland, Middlesboro', Kendal, Hull, Norwich, Stockton, Worcester, and Nottingham. At the first four named, guns are fired; at the others, the current is observed by means of time-balls or galvanometers.

"With regard to the 10 a.m. current, I should have said that there is no rule as to the method of observing; the subscribers use the form of apparatus most suitable to themselves. At the Telegraph Office the signal is recorded or observed on the telegraph instrument."

To this account it is proper to add that wire-communication has been made, experimentally, from the chronopher to the Royal Observatory, so that, by two galvanometers, the time of a current leaving Greenwich and the time of its distribution by the chronopher could be immediately compared. No sensible difference could be discovered. It follows that the hourly time-signals, based upon the most accurate determina ions of time that the Observatory can furnish, may be used for accurate determinations of longitude.

At the Lombard Street Post Office, the Greenwich current at noon *starts* the clock, which has stopped itself some few seconds previously, or at noon of its own time, the clock having a gaining rate. For the guidance of the attendant who regulates the Westminster clock, a signal is received at the Clock Tower from Greenwich, and a return signal is sent to the Observatory by this clock, as well as by the Lombard Street clock, to give us information as to their errors. The errors of the Westminster clock were below 1ˢ on 67 per cent. of days, below 2ˢ on 25 per cent., and below 3ˢ on 5 per cent.; when the error amounts to 4ˢ it can be corrected by the attendant, by lifting a pallet.

The rate of the Mean Solar Standard Clock seems more steady since its inclosure within double sashes.

The demands for the Transit of Venus preparations have been so great that it has been found necessary to increase the staff of supernumerary computers to meet this unusual pressure. At present eight computers are employed in the Astronomical Department, two in the Magnetical and Meteorological Department, and four on the Meteorological Reductions, 1848-1868. A reduction in these numbers will be made very shortly.

The Astronomer Royal is responsible to the Government for everything that passes in the Observatory. An elaborate system of Reports enables him to exercise a constant supervision over all observations, reductions, employ of workmen, and other transactions of the Observatory.

The principal matters to be mentioned in this Section (Extraneous Work) are the preparations for the Transit of Venus Expeditions.

Originally five stations were selected and fully equipped with equatoreals, transits, altazimuths, photoheliographs, and clocks; but I have since thought it desirable to supplement these by two branch stations in the Sandwich Isles and one in Kerguelen's Island; and the additional instruments thus required have been borrowed from various sources, so that now there is an abundant supply of instrumental means.

Telescopes have been lent by the Royal Astronomical Society, by the Cambridge Syndicate, and by Capt. Tupman, Mr. Barnacle, and Mr. Burton (observers in the Transit of Venus Expedition), the last-named gentleman taking out with him a 12-inch equatoreally-mounted reflector.

Transits have been lent by the Royal Astronomical Society and by Messrs. Barclay, Garnelt, Jackson, and Shaw; and an altazimuth by Mr. De La Rue. Other transit instruments have been lent by the Glasgow Observatory and W. R. Birt, Esq., of which it has not been necessary to avail ourselves.

Of double-image-micrometers, five have been made by Mr. Simms, two have been lent by the Royal Astronomical Society, and one each by Mr. Barclay and Capt. Tupman.

There will thus be available for observation of the Transit of Venus 23 telescopes, nine of which will be provided with double-image-micrometers; and five photoheliographs; and for determination of local time, and latitude and longitude, there will be nine transits and six altazimuths.

A model representing accurately the circumstances of the Transit of Venus has been erected on the roof of the Octagon Room, and has been observed regularly since last October from the stage on the top of the Magnetic House. The personal equations of the various observers have been determined, and the different telescopes have been compared, by means of this contrivance. Regular observations of the model have also been made with the double-image-micrometer.

All the observers have undergone a course of training in photography; first, under a professional photographer, Mr. Reynolds, and subsequently under Capt. Abney, R.E., whose new dry-plate process is to be adopted at all the British stations. Capt. Abney has also trained at Chatham 15 non-commissioned officers and privates of the Royal Engineers in all the photographic manipulations required for his process. A Janssen slide, capable of taking 50 photographs of Venus and the neighbouring part of the Sun's limb at intervals of one second, has been made by Mr. Dallmeyer for each of the five photoheliographs.

No magnetical instruments are to be carried out as part of the official enterprize, but some of the observers have furnished themselves with such instruments as their private property.

ON AN IMPROVED METHOD OF CONSTRUCTING THE DEAD ESCAPEMENT FOR CLOCKS.

BY BENJAMIN LEWIS VULLIAMY, CLOCKMAKER TO THE QUEEN, &c.

(Continued from Page 148.)

WE will now proceed to the second part, viz., the Investigation of the circumstances connected with the Theory of this Escapement.

Strongly impressed with the great practical superiority of the dead escapement, when properly constructed and executed, over every other, for clocks with seconds or longer pendulums, I have taken much pains to ascertain whether any rule of general application has been laid down by different authors who have written on the theory and practice of clock work, to determine the distance between the centre of the escapement wheel, and the centre of action of the pallets, which, as far as relates to the theory of the escapement, is of the utmost importance, and not the less so as regards reducing that theory to practice; and generally for determining the relative proportion of the parts of the dead escapement, as usually made for clocks. I regret to add, that my inquiries have not been attended with the success the importance of the subject (as connected with the accurate measurement of time by clocks) had induced me to expect.

The merit of the invention of the dead escapement is, I believe, unquestionably due to that celebrated clockmaker, Geo. Graham, F.R.S., but unfortunately he left no written description of it that I am aware of, and the chief mention I have found of the principle of his escapement is in the works of the French authors.*

* I fully expected some account of this escapement in the Transactions of the Royal Society, of which

Thiout l'ainé, in his *Traité de l'Horlogerie*, 4to, Paris, 1741, on the subject of Escapements, Vol. 1, page 103, thus expresses himself:—"Fig. 19 (Plate 43, Vol. 1), is a dead escapement for clocks, as made by Mr. Graham, clock-maker, of London. The rule I have discovered for making it, and which I apprehend to be a good one, is to place the centre of the anchor at the distance of one diameter of the wheel from the wheel" (that is a diameter and a half of the wheel from its centre), "as shown in the figure. The centre of the anchor must be placed on the perpendicular line, passing through the centre of the wheel, and the wheel cut into thirty teeth, beginning from the above-mentioned perpendicular line; and the teeth which suit the best must be chosen, to determine the place of an arc drawn from the centre of the anchor upon which to form the pallets, which must be so made, that the seconds does not recoil." Here follows a description of the action of the escapement.

From the above, it is evident that M. Thiout's knowledge of this escapement was very limited.

The subject of the dead escapement is entered into at some length by F. Berthoud, F.R.S., of Paris, the author of several horological works. In his *Essai sur l'Horlogerie*, 4to, Paris, 1763, Tom. 1, Première Partie, chap. xxi. No. 397, page 129, he thus expresses himself: "397. The distance between the centre of the anchor of the escapement and the centre of the wheel, depends upon the arc the pendulum is required to vibrate;* if it is to describe large arcs of 10°, for example, then the centre of the anchor must be at B." See Fig. 1, Plate ii. (Berthoud, Fig. 8, Plate xv.)

391. "But if, on the contrary, it is to describe a short arc, of 1°, for example, the centre must be at *a*. See Fig. 2, Plate ii. (Berthoud, Fig. 10, Plate xv.) at the distance of about a diameter and a half of the wheel, A, from the centre of the wheel;† observing, in both cases, that the opening of the compass that describes the rests, or circular faces of the pallets, is such that drawing a line from the point, 5, Fig. 1, Plate ii., through the centre, B, of the anchor, and drawing from its extremity, 5, a line, *z* A, that shall pass through the centre, A, of the wheel; these lines are so situated, that the line, *z* A, shall be perpendicular to the line, 5 B;* and by

Mr. Graham is a member; but by reference to the Index of the Transactions, there is no mention of Clock Escapements; at which I am the more surprised, as there is a communication from Mr. Graham on the subject of his invention of the Mercurial Pendulum, and the measuring the lengths of pendulums at different places. Mr. Graham was the immediate successor to Tompion, and the art of Clock and Watch-making is so much indebted to him for its advancement, that I consider it due to his memory to insert the following memorandum:—He was born in 1675, was elected an Assistant of the Court of the Company of Clock-makers of the City of London, the 18th April, 1716, and served the office of Master of the Company, 1721 and 22; was elected a Fellow of the Royal Society the 9th March, 1728, and died the 16th November, 1751. His remains were interred in the aisle of Westminster Abbey.

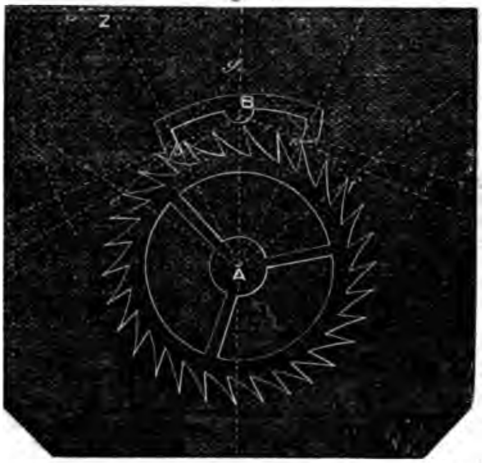
* This is not perfectly well expressed, as by the arc the pendulum is required to vibrate might in his case, mean the arc the pendulum must describe, to enable the pallets to escape; or, in other words, the quantity the pendulum is led by the action of the wheel upon the inclined planes of the pallets, and not the total arc of the vibration of the pendulum; (at No. 399 and 400, M. Berthoud describes the difference between the total arc of vibration of the pendulum and the arc led by the action of the wheel upon the pallets), neither is this a correct statement, for the quantity the pendulum is led by the action of the wheel upon the pallets depends upon the angle of lead of the pallets, or the length of their inclined planes; as well as upon the distance between the centre of action of the pallets and centre of the wheel, and consequent number of teeth the pallets take over. In illustration of this (See Fig. 3, Plate iii.) to the same wheel are applied two pairs of pallets, which, taking over a different number of teeth of the wheel, are consequently at different distances from the centre of the wheel; and yet, from the difference of the angle of lead of the pallets, the pendulum will be led an equal quantity by the action of the wheel upon either pair of pallets; the difference between the angles of lead of the pallets compensating for the difference between the distance at which each pair of pallets is placed from the wheel. In the figure the four triangles, B A C, D A E, F W G, and H W I, which express the angles of lead of the pallets, are drawn equal to one another, and equal to the triangles, K A L and N W M, also equal to one another, which show the quantity the pendulum is led by the action of the two pair of pallets, on each side of the perpendicular line, A X.

† I believe that Mr. Graham, Mr. Shelton, who worked with him, and most of the clock-makers of that period, who trod in the footsteps of Mr. Graham, in the construction of their seconds pendulum clocks (the scape-wheels of which were necessarily cut into thirty teeth), made their pallets take over eleven, twelve, and thirteen teeth of the wheel; and the distance between the centres was one diameter of the wheel in the case of taking over eleven teeth; about one and a half diameter in the case of taking over thirteen teeth: and between one diameter and one diameter and a half in the case of taking over twelve teeth. The French clock-makers, who copied Graham's escapement, followed nearly the same rule.

* (See Fig. 1, Plate ii.) In the case of the anchor, whose centre motion is at B, M. Berthoud determines the centre of action of his pallets by the intersection of two tangents drawn from the points where the circle of the inner rest of the pallets prolonged intersects the circle than circumscribes the wheel. By this mode the two centres are nearer together that they would have been had he determined their distance by tangents drawn from the points

the same rule, if the anchor is placed at *g*, the pallets, or inclined planes of the anchor, should act upon the wheel at the points, *e f*; this understood, the portions of the circles, 1 C, 3 D, Fig. 2, Plate ii. (M. Berthoud transfers his description to Fig. 10 of his work,) must be drawn of the same radius, *a* C; and in the same manner, 2, 5, and 6, 4, taking care that the space, or thickness, C 5, 6 D, between these portions of circles, is a little less than half the interval between the teeth of the wheel.

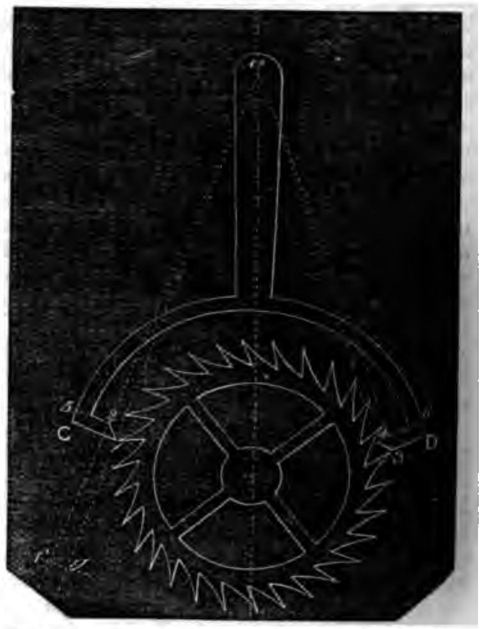
Fig. 1.



"Now, to determine the inclination of the planes, from the centre, *a*, Fig. 2, draw the straight lines, *a f* and *a g*, forming the angle, *f a g*, being half the angle the pendulum is required to be led; † through the points 2 and 1, where these lines intersect the arcs, 2, 5, and 1, C, draw the straight line, 2, 1, which gives the inclined plane, 2, 1, by a similar operation, the inclined plane of the other pallet is obtained. There are several other practical methods, which are easy of application, but difficult to explain."

And again, at Nos. 1324 and 1325, page 449 (in what follows the scape wheel is supposed made, and the original text is abridged, such parts only being translated as immediately relate to the laying down of the lines of the escapement), "To draw the anchor piece of the escapement" (Berthoud here supposes the drawing to be made upon a brass plate, and distance between the centres already determined), "the distance on the pillar plate between the centre of the scape wheel and the centre of the verge of the pallets must be taken: * from the centre, *a*, of the anchor, see Fig. 3, Plate ii (Berthoud, Vol. ii. Plate xxiii. Fig. 3; part of Berthoud's figure is omitted, no more being drawn than immediately relates to the text), the line, *a b*, must be drawn just to touch the circumference,

Fig. 2.



b c, of the wheel; if, from the point, *b*, where the two lines touch each other, the radius B *b*, is drawn, it will be perpendicular to *b a* (as may be geometrically demonstrated), and, conformable to mechanical principles, the action of the wheel upon the pallets should be at the point *b*; consequently, *a b* is the length to be given to the arm of the anchor, to enable the wheel to act upon the pallets in the most favourable manner possible."

1326. "Place the wheel in the plate with its centre on the point, B, then place one of the points of a pair of compasses on the centre, *a*, of the pallets, open the compasses

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where the circle of the outer rest intersects the same circle. That the points found by the intersection of tangents drawn from either of these points is not the proper centre of action of the pallets, will be shown hereafter,—in the one case the centres are too far apart; in the other case they are too near together.

† See note, page 3.

* From this it would appear that M. Berthoud's plan is to determine the distance of the two centres from each other on the plate of the clock, and then to adapt his escapement to those distances; which, as the number of the teeth of the wheel is regulated by the length of the pendulum, to preserve the angles, B 5 A, B 6 A, *g e* A, and *g f* A, Fig. 1. Plate ii., right angles, can only be done by making the pallets take over a greater or lesser number of teeth; or, if necessary, by altering the size of the wheel; or, if this cannot be done for want of room or any other cause, then, and quite contrary to his leading principle, the angles, B 5 A and B 6 A, &c., must be increased or diminished.

quantity, *a c*, and turn the wheel on re, B, until the front of one of its ets the other point of the compasses circle of the wheel at *b*; that done, e wheel immoveable, transport the int of the compass to the other side, if it will reach the back of the point er tooth at *c*: if it does not, the of the compasses must be varied until es from the centre, *a*, at the same the points of the two teeth, the to the points, *c* and *b*: draw the porcircles, *b t*, *c p*, which will represent he circular faces of the pallets." *

"To find the other two circular opening of the compasses must be n such a manner that the teeth of

Fig. 3.

l having advanced a quantity equal he interval between them, they pass portion of a circle drawn from the tre, *a*, and intersecting the circle of l; but, as that may equally be done ng or closing the compasses, a quanl to the space between two teeth, it able to use that of the two openings, ill occasion the distance of the lines centre to vary the least from the and *b*, which points are to be varied little as possible. That done, trace two faces of the pallets, *d s* and *e g*, † e here, by preference, drawn within rs, to diminish the space the anchor ove, and, consequently, the friction of ts. In this manner are described the ular faces of the two pallets, placed a manner as to let the teeth of the wheel alternately escape as the pallets approach and recede from the centre of the wheel by the action of the pendulum."

1328. "The length of the pallets is regulated by the quantity of the angle of lead that is to be given to the escapement, which we will here suppose of 5° on each side, or thereabouts."

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is not correct, because *c p*, Fig. 3, Plate ii., ce of the pallet.

gain is incorrect; *d s*, Fig. 3, Plate ii., is of the pallet, and cannot be considered as

Letters to the Editor.

All letters to be addressed to the Editor, at the Institute, 35, Northampton Square, E.C.

To the Editor of the Horological Journal.

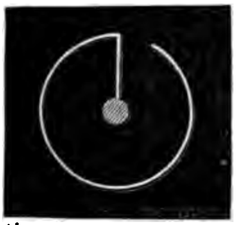
Sir,—Will the enclosed convey any information to your American correspondent named in the January number of your *Journal?* It is the copy of a little bill tacked inside the door of a very good 8-day clock in an exceedingly fine japanned case, bearing the name of "William Tomlinson, London."

J. PADBURY.

Bishop's Waltham.

Directions to set up and keep a Pendulum Clock.—Set it upright so that the pendulum may hit against both sides of the case alike; make it fast to the wall, and that the ball of the pendulum may be just free of the back of the case on the inside. Wind it up once in a week. Never move the hour hand, but turn the minute hand. Turning the minute hand round moves the hour hand one hour. When there are not 31 days in a month, move the month circle with the point of a pin till right; or if the day of the month be shown with a hand, move the hand till right. If the clock goes too fast screw the ball of the pendulum a little lower at a time till you find it right; but if it go too slow screw the said ball a little higher as experience will teach. If the day of the month happen to move in the day time turn the minute hand twelve times round, which will make the clock strike twelve times, and will make it move in the night. If the clock strikes wrong take off the head of the case and turn with your finger one of the round P's of steel that go across the body of the clock, which will cause the clock to strike, which may be done until right with the hand. The said clocks, with all other sorts, and all sorts of watches, are made by William Tomlinson, at the "Dial and Three Crowns," in Birchin Lane, near the Royal Exchange, London, now in "White Hart" Court, Gracechurch Street.

Sir,—Referring to Mr. Fewtrell's reply to "Tempus," which appeared in the June number of the *Journal*, for the lifting part of Davis' Patent Lever Clock, there is a lifting pin sticking out from the centre pinion as usual in a Yankee clock, but attached to this pin (in fact a continuation of it) is a ring or circle of wire; the circle, however, is not quite complete, leaving a small space, forming what may be called a notch, into which one end of the lifting piece drops. The lifting began about ten minutes after the hour, the wire ring keeping the clock on the warning for about 50 minutes. The secret of getting the clock to strike correct is to attend to the twelve and one first, regardless of the other numbers; and, after setting the clock going, to pay no attention to two or three hours the clock strikes at first, but after that time you may expect it to strike regularly. It is a queer affair. I met with a few of them in the States, and I think only one in England.



Croydon. JABEZ STARK.

Sir,—In England open competition trials are instituted for marine chronometers at the Royal Observatory, for the purpose of being purchased by the Admiralty. At the Liverpool Observatory rates are certified for chronometers in different temperatures.

At the New Observatory certificates are given for the correctness of thermometers and barometers at a specified charge. Perhaps your readers may feel interested in what has been done during the last few years at the Observatory of Geneva.

Annual trials for pocket chronometers, under the superintendence of Professor Plantamour, the director of the Observatory, now take place. This year fifty-three chronometers have been sent in for competition. They remain forty-five days at the Observatory, and are submitted to the following tests:

1st. The mean variation from one day to another during forty-five days, whatever may be the position or temperature, the limit fixed to enable them to compete, 0·8 sec.

2nd. The error corresponding to a difference of one degree of temperature, centigrade, with a limit imposed of 0·2 sec.

3rd. The difference of rate in the horizontal and vertical positions, with a limit of 2 sec.

4th. The correctness with which a chronometer resumes its former rate, after having been placed fifteen days in a different position, with a limit of 1·5 sec.

5th. The correctness with which a chronometer resumes its mean rate, after having passed through the oven, with the same limit of a second and a half.

If a chronometer exceeded the limit of any one of these trials it was rejected. The mean of all the trials determined the classification, a slight importance being given to the first.

In the competition this year four prizes were awarded. The first, of 150 francs, was obtained by Messrs. Badollet with a watch having the English Lever Escapement, and the balance spring turned according to Philipps' formula. It was adjusted by Francois Vindone. The first proof gave an error of 0·28 sec.; the second proof 0·10; the third 0·4 sec.; the fourth 0·32 sec.; and the fifth 0·54 sec. This is the third year that a chronometer adjusted by M. Vindone obtained the first prize, and it may be added that this watch remained three months at the Observatory, and its variation diminished.

Two second prizes, of 100 francs, were awarded, one to M. Jules Romieux for a chronometer adjusted by himself, the errors of the five proofs being:—0·42 sec., 0·01, 0·23, 1·41 and 0·52 sec. The other was given to M. Em. Paintard for a chronometer adjusted by himself, the errors being:—0·51 sec., 0·06, 0·07, 0·08, and 1·49 sec.

A third prize, of 80 francs, was gained by Mr. John Darier for a chronometer, the adjuster of which declined to give his name, the results of the five proofs being—0·61 sec., 0·23, 0·06, 0·14 and 0·54 sec.

This year, for the first time, a second competition was instituted. It consisted of taking the mean of all the rates of the chronometers sent in by each manufacturer, providing that not less than three were submitted. The tests were not so severe for these as for the single chronometers. Six manufacturers entered into this competition, the two best being so nearly equal that the prize was divided between them. The successful competitors were Messrs. Badollet, who sent in seven chronometers, six of which were adjusted by M. F. Vindone and one by M. J. Rambal, and M. R. Ekegren with five chronometers, four being adjusted by M. A. Favre, and one by M. R. Ekegren. The mean variations of the seven chronometers of Messrs. Badollet for the five trials were—0·486 sec., 0·120, 1·877, 1·141, and 0·546 sec., and those of the five of M. Ekegren —0·536, 0·078, 1·140, 2·116, and 1·054 sec.

I presume that all these watches have going barrels, and although called chronometers, that they are all, or nearly all, English lever escapements.

R. WEBSTER.

Queen Victoria Street.

.N IMPROVED METHOD OF CONSTRUCTING THE DEAD ESCAPEMENT FOR CLOCKS.

By BENJAMIN LEWIS VULLIAMY, Clockmaker to the Queen, &c.

(Continued from Page 174.)

(This part is very much abridged ranslation.) "To describe the angle ment, prolong the line, *a b* to *f*. 3, Plate ii.,* and draw the angle, *f a g*, e point *d*, where the line, *a g*, inter- e inner circular face of the pallet, es the length of the pallet; for the n passing the pallet, causes it, by its n the inclined plane, to describe an 5° to have the inclined plane, draw , *d b*, passing through the points, *d* here the straight lines, *a f* and *a g*, rm the angle, *g a f*, intersect the por- ircles, *d s* and *b t*."

"To draw the inclined plane, *c e*, it observed, that, as the pallet, *d b*, is within the circle of the wheel, it that the pallet, *c*, must be situated the same circle, and ready to come on as the other pallet escapes from the Prolong the line, *a*, *c* to *h*, and draw e, *h a i*, of 5°, which will determine sure of the inclined plane, *c e*; it n remains to draw the line, *c e*, which rough the points, *c* and *e*, where the lines, *a h* and *a i*, intersect the por- circles, *c p* and *e q*: thus will be e inclined plane which is to terminate et, and so situated that when the ?, shall have led the pallet without e of the wheel, a quantity equal to of 5° the pallet, *c e*, shall also be led of 5°, and within the wheel; conse- when the tooth, *r*, shall have led the escape, the pallet, *c*, will have des- a angle of 5°, whence it follows that lead of the escapement will be 10°"†

1331. "The escapement thus drawn will be a dead escapement, because it is formed of portions of circles concentric to the point, A (396), but," &c.

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* 1, 2, and 3, in the July number of the were reproduced from Plate ii. of the author.

† is a mistake; the total quantity the pen- led being an angle equal to the angle of ther of the pallets; (it is supposed that the the two pallets are equal to one another, ght to be) and the pendulum is led nearly angle, ascending and descending on each ro (or the perpendicular line on the degree each pallet alternately; but the advance heel, and, consequently, the friction upon ed planes of the pallets, is not uniform e ascending and descending of the pendu- ach vibration, but exists upon a greater n of, and is consequently greater upon, the the pendulum ascends than as it descends; osing the inclined planes of the pallets t that point which the extremity of the tooth of the scape-wheel has reached when the pendulum is perpendicular, the portion of the inclined planes the tooth of the wheel acts upon, as the pendulum descends, is less than the portion acted upon as the pendulum ascends. It is possible to make the inclined planes of the pallets so long that the angle of the total vibration of the pendulum will not exceed the angle of lead of the pallets, in which case it will be visible that the total angle the pendulum is led is only equal to the angle of one of the pallets. M. Berthoud has fallen into the same error

Fig. 1.—Plate iii.

at No. 399. To illustrate as much of the above as refers to the irregularity of the friction upon the pallets, suppose Fig. 1, Plate iii., the pendulum at rest, and perpendicular upon the line, X W, bisecting the angle, Y X Z (which angle is equal to the angles, B X P and D X Q, of lead of the pallets), and the lines, A B and C D, the inclined planes of the pallets; the dotted lines, E F and G H, will represent the lines of the inclined planes, when the pendulum subtending the line, X Z, is led to the extremity of the lead one way; and the dotted lines, I K and L M, the inclined planes when the pendulum subtending the line, X Y, is at the extremity of the lead in the other direction (it cannot be to often repeated that the angle of lead must not be confounded with the angle of vibration), and the points, N and O, where a supposed circle, circumscribing the points of the teeth of the wheel, intersects the inclined planes, A B and C D, are the points upon one of which (determined by the pallet from which the wheel has last escaped) the wheel will be in contact with the pallet, when the pendulum, having advanced half the angle of lead, subtends the perpendicular line, X W. Now it is visible that the portions, N A and O D, of the lines, A B and C D

The late Mr. Cumming, F.R.S.E., in his *Elements of Clock and Watch Work*, London, 1766, page 43, No. 176, states that Graham made his pallets take over twelve teeth. In his Plate ii., in which he represents the dead escapement drawn very large; and in detail, Mr. Cumming places the centres at the distance of exactly one diameter of the wheel apart, and makes the pallets take over eleven teeth; and in a note, p. 44, he thus expresses himself: "Fig. 3, Plate iii. (Cumming's Work) exhibits at one view the length of the pallet and the distances of the centre of the verge from that of the swing wheel, according to the number of the teeth of the wheel which the pallet takes in, from two to twelve.* (the wheel is supposed a wheel of thirty teeth), by which it appears that the distance of those centres is the secant, and the length of the pallets the tangent of half the angle subtended at the centre of the swing wheel by such number of teeth." To illustrate Mr.

Fig. 2.—Plate iii.

* In the plate of Mr. Cumming's work, the number of teeth taken in by the pallets is from three to thirteen, not from two to twelve, as stated in the text, and as marked in figures in the plate. Fig. 4, Plate v., represents the tangents drawn, taking in from two to twelve teeth, as quoted in the text, Fig. 5, taking in from three to thirteen teeth, as represented in Mr. Cumming's figure. It is worthy of notice that in the case of taking in thirteen teeth the distance between the centres, supposing the tangents drawn from the points of the teeth (see Fig. 5, Plate v.), is not exactly 1 and ½ diameter of the wheel, the distance determined by the supposed rule of Graham's, but a little more.

which are the parts of those lines the teeth of the wheel act upon when the pendulum ascends, are greater than the lines, N B and O C, which are the portions the teeth of the wheel act upon when the pendulum descends; consequently, the velocity with which the wheel advances is not equal during equal portions of the lead of both pallets. By altering the shape of the inclined planes of the pallets from straight lines to portions of circles the advance of the wheel may be made nearly proportional to the advance of the pendulum. Suppose, Fig. 1, Plate iii., the pendulum to subtend the perpendicular line, X W, and, consequently, to have vibrated half the angle it is led, and the inclined plane of the pallet, Æ, instead of being the straight line, D C, to be a portion, D T C, of a circle, passing through the three points, D S (where the radius, R V, bisects the arc, M G, of a supposed circle circumscribing the wheel), and C; the consequence resulting from giving this shape to the pallets will be, that the wheel will have advanced to the point, S, half its total advance, and have acted upon very nearly half the surface of the pallet, when the pendulum has vibrated half the angle it is led; for the portion, C S, of the circular face of the pallet upon which the wheel has acted during its advance from the point, G, to the point, S, is less than the portion, S D, of the pallet upon which it must act during its advance from S to D, by the quantity, S T; which difference between the arcs, C S and S D, is very trifling, when compared with the difference between the straight lines, C O, and O D, which form the inclined plane, C D. The same effect takes place in the pallet A B, but, from the relative position of the parts, in a much less degree; the circular face of the pallet requiring to be a portion of a much larger circle: and here it is worthy of notice, that the faces of the two pallets being portions of different circles, the one is, in fact, a longer line than the other, and consequently, with circular faces, as just described, there is more friction on one pallet than on the other; and more on both than when the acting faces are straight lines. The proportional advance of the wheel and pallets was probably considered by Mons. L. Berthoud (chronometer maker to the French Navy during the period of the Republic), of great importance in the case of the dead anchor escapement, when applied to watches; he having given this shape to the pallets of some of his box marine chronometers, that I have had an opportunity of seeing. The friction is also unequal upon the rests of the pallets, without regard to the shape of the inclined planes, whether straight or curved: for the arc of vibration on each side of zero on the degree plate must necessarily subtend equal angles, and the angles of lead on each side of zero being also equal, it necessarily follows that the angles of rest must be equal; but the rests of the pallets being at unequal distances from their centre of motion of a quantity equal to the thickness of the pallet, it also follows, that though the arcs which subtend the angles of rest subtend equal angles, yet, that one of them must necessarily be larger than the other, being a portion of a larger circle; and consequently, the friction greater upon the one than upon the other; the difference, however, is very small, and this is an evil that from the construction cannot be avoided. It is scarcely necessary to add that for the clock to be in beat it is requisite, not only that the angles the pendulum is led should be equal, but that the angles of rest, on the circular faces of the pallets, should also be equal; otherwise, the total angles of vibration on each side of zero, on the degree plate (which represents the perpendicular line when the pendulum is at rest), will not be equal, and consequently, not be performed in equal times. The above observations will, I believe, be found to be of universal application in this construction of the dead escapement. For further illustration on this subject of the angle of lead, see "Astronomical Observations," by the Rev. Wm. Ludham, 4to., Cambridge, 1769, note, page 86.

ing's observation respecting the secant agent of half the angle of the number h taken over; suppose the case of the taking over twelve teeth (see Fig. 4, v.), D C, the distance between the will be the secant, and D B, the of the supposed pallets, the tangent to gle, A B C, which angle is half the subtended at the centre of the wheel h number of teeth. Here, Mr. Cumdetermines the centre of action of the by tangents drawn from the points of th of the wheel; which, as will shortly wn, is not the most correct method.

.. Le Paute, in his *Traité d'Horlogerie*, ris, 1767, p. 188, No. 58, states, that aham made his dead escapement for with the rest at equal distance from tre of action of the pallets, as repre- Fig. 2, Plate iii., and has so repre- them in Plate xiii., Fig. 9, of his

Fig. 3.—Plate iii.

tever advantage may be supposed to from the rests being at equal distance he centre, it is more than counter- d by the inequality of the distance he centre of the pallets, at which the e is given by the wheel. In the first this difference of distance causes the s of the inclined planes to be different ach other (see Note page 3, and Fig. 3, iii., where the same effect is more shown), and in the second, and this ost material objection, would entirely t the application of the rule about to wn for determining the distance between tre of the wheel, and the centre of the

Ferdinand Berthoud, in his last and great work, *L'Histoire de la Mesure du Tems*, 4to, Paris, 1802, in Vol. ii., page 26, speaking of Graham's escapement, which he does very briefly, thus expresses himself, quoting M. Thiout, "La règle qui j'ai trouvé (dit M. Thiout), et qui me paroit assex convenable est d'eloigner le centre de l'ancre de la circonférence de la roue d'un diametre du rochet comme la figure le représente." This is translated at page 2, under the head of M. Thiout.

In Dr. Rees' Cyclopædia, 4to edition (Vol. xiii., Part ii.), under the head of "Escapement," among other escapements described is the "Anchor Escapement, by Clement, or Dr. Hook," and "Graham's dead beat." In the first, it is inferred, that the distance between the centres of the pallets and scape-wheel, regulates the arc of vibration of the pendulum. This, as has been before observed, is not the case (see note, page 3); and in both, that the distance "is determined by tangent lines." This cannot be better explained than by the following quotation from the explanation of "Graham's dead beat," which applies equally to the principle upon which the anchor escapement is constructed. "In this construction, as in the preceding one, the distance of the centres of motion, *a*, *b*, (Fig. 4, Plate xxxii., Rees' Cyclopædia) is determined by the tangent lines meeting the radii at the points of the acting teeth; when the distance is an exact diameter of the escapement wheel, we find that the pallets take in just ten teeth out of thirty, which is the case in the figure before us; but when twelve teeth are taken in, the centre of the anchor's motion falls at *h*, just a diameter and a half from the centre of the wheel." This is not correct, for it will be found, by reference to Fig. 4, Plate v., that when the pallet takes in ten teeth, the centre of motion of the pallets, determined by "tangent lines," is at a distance from the centre of the wheel, considerably less than a quantity equal to one diameter of the wheel; and, that when the pallets take over twelve teeth, the distance is considerably greater than one diameter of the wheel. Also, by reference to Fig. 5, that when the pallets take over eleven teeth, the distance is exactly (or very nearly so) one diameter; and when they take over thirteen teeth, a little more than one and a half diameter of the wheel. It is unnecessary to make any remarks on the continuation of the description of "Graham's dead beat," with regard to Berthoud's rule, after the notice that has been taken of Berthoud's account of the dead escapement at the beginning of this paper. In the representation of Graham's Escapement, in Rees

Plate xxvii., Fig. 4, before mentioned, the centre of the pallets is placed at one diameter of the wheel, from the centre of the wheel, and the pallets take over eleven teeth. In the representation of the anchor escapement, Fig. 3, the pallets take over ten teeth, and their centre of motion is less than one diameter of the wheel from the centre of the wheel.

It may be considered requisite, in reference to the subject, that some notice should be taken of the escapement under the denomination of "Modification of the dead beat, by Grinion," described immediately after Graham's dead beat. I shall content myself with observing that Mr. Grinion describes his dead escapement as constructed on the same principle as I.A. Le Paute states Graham to have made his (see page 10, and Fig. 2 Plate iii.), with the rests of the pallets at equal distance from their centre of motion, and with the centre of the pallets placed at the distance of one diameter of the scape-wheel from the centre of the wheel. In the figure (see Fig. 5, Plate xxxii., Rees' plates), the pallets are represented with the angle of lead of both pallets entirely within the periphery of the circle of the wheel; with the pallets so constructed, the point of the tooth of the wheel would drop on the rest of the pallets, at a very considerable distance from the inclined plane, and, consequently, the friction be very much increased; and, moreover, the pendulum must vibrate a very long arc, to enable the pallets to escape at all.

"Bennet's dead beat," represented Fig. 7, is also in the same case with the angle of lead of both the pallets, entirely within the periphery of the circle of the wheel.

I apprehend a very general and correct rule, and one easy of application, for determining the distance at which the centre of action of the pallets ought to be placed from the centre of the scape wheel, and for drawing the lines of the dead escapement, may be given.

Having determined the diameter of the wheel, the number of its teeth, and the number of the teeth of the wheel the pallets are to take over, draw a circle circumscribing the points of the teeth of the wheel, and upon this circle at the proper places as determined by the opening of the pallets, mark the thickness of the pallets, which, making no allowance for drops, should always be half the space between two points of the teeth for each pallet; that done, draw two straight lines between the points that mark the thickness of the pallets upon the circumscribing circle; these lines will be chords to the portions of the circle they subtend; prolong these two lines until they intersect each other; the point where they meet will be the proper centre of motion for the pallets. Next, to describe the circular faces of the pallets; from the centre of motion as above determined, draw portions of two circles that shall intersect the circle circumscribing the wheel at the four points which mark the place and thickness of the pallets. The angle of lead, which is quite optional, must then be determined—this is done by drawing two lines from the centre of action of the pallets; the one within and the other without the lines by which the said centre was found, and forming with those lines two equal angles: the angle of lead determined, it now only remains to draw the inclined planes or acting faces of the pallets; this is done by drawing two diagonal lines from the upper to the lower points of intersection of the lines forming the sides of the two angles of lead, by the circular faces of the pallets.

The clock in the tower of St. Pancras Terminus, Midland Railway, began to mark the flight of time on the last day of June, and a few days later it was illuminated. This lofty tower, with its luminous dial, is a prominent object at night from the high ground in the outskirts of London.

Transmission of Jewellery, &c., in Letters.—Information has been received from the Post Office of New South Wales that watches and jewellery are no longer liable to Customs duties in that colony, and that there is now no objection to letters containing such articles being forwarded in the mails to New South Wales. Consequently the prohibition against sending such articles to New South Wales in letters which was imposed in the January of last year is withdrawn.

A man named Collingridge has been found guilty by a jury, at the Old Bailey, for forging the name of "Charles Frodsham" upon a watch. The evidence discloses that after an unsuccessful attempt to pledge it with Mr. Attenborough, who detected the forgery, the watch was pawned, and the ticket sold. The purchaser of the ticket upon redeeming the watch took it to Messrs. Charles Frodsham and Co. to repair, who detained it, and instituted inquiries, resulting in the apprehension of the man Collingridge, who is admitted to bail pending the consideration of a technical point raised in his defence. A singular point in the case is that the watch was actually made by Mr. George Moore, of St. John's Square, who has since taken the business carried on by Charles Frodsham.

THE TRANSIT OF VENUS.

[From the *Times*.]

Several Government expeditions, very carefully prepared and equipped, will shortly start from the Royal Observatory at Greenwich for remote parts of the globe, in order to observe the transit, or passage across the sun's face, of the planet Venus, early in December next. In preparation for this enterprise, a staff of astronomers and photographers, composed of officers of the Naval and Military services, with a sprinkling of civilians, have been working at the Observatory for some months, under the guidance of Sir George Airy and his assistants, practising themselves in the complicated observations and other delicate processes which will be required of them, and upon the proper accomplishment of which so much that is important in astronomy depends. In itself, the grand problem of the accurate determination of our distance from the sun, and thence of the distances of the planetary bodies and of those few of the fixed stars whose remoteness can be gauged at all by any means yet known to science, must have attractions for every intelligent mind. The interest and curiosity naturally appertaining to the question have been, moreover, not a little stimulated on this occasion by the articles and letters on the general subject of the Transit which have been published during the last year in our own columns and elsewhere. Enough, certainly, has been told to whet the appetite of the public for further details. For the information, therefore, of those of our readers who cannot go to Greenwich and learn these things for themselves, we propose giving some account of the energetic and complete arrangements which England and other countries are now making for the observation of one of the most rare and scientifically valuable of celestial phenomena.

Probably most persons are aware by this time that of the three or four different methods by which the Transit may be oberved, the one known as Delisle's is that on which England, in common with the majority of other nations taking part in the work, will place chief reliance on the coming occasion. Due regard will be given to the Halleyan method as well as those points where the whole Transit will be visible, as will be the case at all of our southern stations; photography also will be very generally used; but the Astronomer Royal's choice of stations has mainly been made on the basis of their cuitability for the method of Delisle. Briefly and popularly, this consists in the accurate determination of the interval, of time which elapses between the moment when some instantaneous phase of the Transit is seen from one point on the earth's surface, and that at which the corresponding phase is seen from another point far distant from the first, a necessary condition being that this time-interval shall be as great as circumstances will admit of. The two phases most suitable for observation are, —firstly, the apparent entry or "ingress" of the planet on the sun's surface; and, secondly, her departure or "egress" from it; and the critical moments to be seized are, in the first case, those at which, from different stations, the planet's hinder edge, or "following limb," is seen exactly in contact with the sun's edge on one side; and, in the second case, those at which, from other stations, her advanced edge, or "preceding limb," is similarly seen in contact on the other side. In other words, they are the first and last moments, respectively, at which, from the several points, the whole disc of the planet is seen just within the sun's rim. A crown-piece laid on a large round table, touching its edge, first on the left hand and then on the right, will serve to illustrate the above phases, which are called those of "inferior contact" at ingress and egress respectively.

That the reader may now understand something of the conditions which govern the choice of stations, let him conceive a plane to pass through the centres of the earth and sun, and through the centre of Venus at the moment when she first arrives within a conical surface similarly imagined to envelope the circumferences of the earth and sun. This plane will evidently cut the edge of the illuminated half of the earth in two points diametrically apart. And since Venus, moving faster than the earth, crosses the sun's face from east to west, it is also evident that an observer placed at the eastern extremity of this diameter will witness her ingress sooner than he would from any other point on the globe; while an observer at the opposite or western end will sensibly be the last to see it —neglecting, for the sake of brevity, the slight change introduced by the earth's axil rotation, and by her own and Venus's proper motions in the interval, none of which, however, may be overlooked in practice. The one would see the interior contact at ingress "most accelerated;" the other the same phase "most retarded." Geometrically, therefore, these would be the best points for a pair of observations of the ingress. But, as this ingress has to be observed from the two stations at nearly the same time—for the interval between the most accelerated and most retarded ingress in the coming. Transit will be only some 25 minutes—it follows, from the nature of the case, that to each of the two observers,

thus situated 180 degrees apart from one another, the sun will be but barely above the horizon at the critical moments. To the eastern observer it will be just sunset, to the western one sunrise. But, inasmuch as it is a necessary condition, consequent on the distortion of the sun's image at very low altitudes, that it should be not less than about 10 degrees above the horizon, our observers must be placed at points somewhat nearer together than a full diameter of the earth. The best points for observation of the egress also are determined on exactly similar principles. In every case, however, the theoretical conditions are, of course, limited in practice by the possibility of finding land near the desired spots which can be reached and occupied with safety by the observing parties: the observations, to be trustworthy, can only be made on *terra firma*. It may be worthy of remark, with respect to the last matter, that the Astronomer Royal, and those who act with him, determined at the outset not to attempt to send expeditions to points destitute both of inhabitants and anchorage, though they were willing to put up with the absence of either the one or the other singly, as, indeed, is shown in the case of three of the stations already chosen. We must not omit to mention, lastly, that the prospects of fine weather at the season of the Transit have also to be taken into account in the choice of stations.

Supposing, now, that the absolute time-interval between a pair of observations of accelerated and retarded ingress or egress, as the case may be, has been ascertained, as well as the distance separating the two stations, and remembering also that the *relative* distances of the Earth and Venus from the sun and their heliocentric angular velocities are already exactly known, we have at once, by simple geometry, the chief data necessary for the computation of the sun's distance, though the actual reduction, atmospheric refraction, and other causes, which cannot be dwelt upon here.

Guided by conditions such as we have indicated, the Astronomer Royal has chosen five principal and three subsidiary stations for our share in the enterprise. Honolulu will be the chief station for observing the accelerated ingress, and it will be strengthend by secondary stations at two other points, probably Hawaii and Atooi, in the Sandwich Islands. The retarded ingress will be observed at Rodriguez Island near the Mauritius, and at Christmas Harbour in Kerguelen Land (sometimes called the "Island of Desolation"), in the Southern Ocean; with a station auxiliary to the latter at some second point on the same island. Lastly, Christchurch (New Zealand) and Alexandria will pair together for the accelerated and retarded egress, supported by independent observations which will be made in Australia and Northern India. As Delislean stations, all of the above are excellent. For Halley's method, Kerguelen and its satellite, though not of first-class value, are good, probably the best practicable, southern stations; Christchurch and Rodriguez are of inferior value in this respect; and the rest are excluded, the whole transit not being visible from them. Parties, each consisting of a chief astronomer in charge, at least one solar photographer, and from one to three or four assistant astronomers, will be sent to the five principal stations. There will also be attached to each party two or three sapper photographers from the Royal Engineers, a number of whom have been under instruction at Chatham by Captain Abney, R.E., in the use of the photoheliograph and the manipulation of sun-pictures. Sir George Airy's arrangements for the personal staff are not yet complete, but, so far as is decided at present, Captain Tupman, R.M.A., a well-known member of the Astronomical Society, will conduct the Honolulu party, and will be accompanied by Professor George Forbes, of the Andersonian University, Glasgow, and others. Lieutant Neate, R.N., is nominated as chief for Rodriguez; and the Rev. S. J. Perry fills the corresponding office for Kerguelen. The stations subsidiary to Honolulu and Kerguelen will be served by detachments from the main parties. Major Palmer, R.E., will have charge at Christchurch, and Captain Ord Browne (late R.A.) at Alexandria; Lieutant Darwin, R.E., and Captain Abney, R.E., respectively undertaking the photographic work at these two places. At the outset of the enterprise, several full-pay officers of Artillery and Engineers, nearly sufficient in number for the entire staff, and all of them more or less qualified by previous knowledge, volunteered to take part in it, and we believe that Sir George Airy was anxious to avail himself of the services of a class of observers whom experience had shown to be well fitted for work of the kind. But at this point the Admiralty or the War Office, or both together, failed him. With the three exceptions we have named, the services of these officers were refused, on the score of expense, and as an alternative a call was made for volunteers from officers of the Royal Navy. Fortunately, men of energy and ability responded to this appeal, and have since applied themselves to the work with a zeal and industry which give the best possible promise of success.

In the preparation and equipment of the

sit parties, the vigilant forethought of the nomer Royal seems never to have relaxed. only is the instrumental outfit probably argest and most perfect of its kind which ver been brought together, but even in ct of those minute details which contri- so much to accuracy and success in an prise of this kind, nothing seems to have forgotten or neglected. When we men- for example, that, in addition to the tless other duties of his arduous office, George Airy has contrived to give his onal attention to such matters as designing portable observatories for the various ruments, and devising the best positions the doors and windows of the photohelio- h-huts and "dark rooms," according to different latitudes and different hours of day for which they will be required some may be formed of the amount of work ch has fallen upon him, and of the thought- care with which the practical details have n planned and executed.

Besides such smaller items of equipment as ched telescopes, portable transit instru- ts, telegraphic apparatus, compass, chrono- ters, barometers, &c., four chief instruments, h with its portable observatory, solid stone tform, astronomical clock, and other essary gear, will be sent to all the principal tions. First in order come the Transit truments, of forty inches focal length and ee inches aperture, mounted on massive ne piers. These will be used for finding e by the transits of stars, and longitude transits of the moon. We have seen that is an essential condition of Delisle's method t the *relative* time at any pair of stations ll be exactly known. Astronomers adopt eenwich time as the absolute standard of nparison for this purpose. But, as Green- ch time cannot be carried accurately all er the world, it is inferred at distant places m the local time combined with the sup- sed longitude. Alexandria is the only one our Transit stations the longitude of which n as yet be determined by telegraphic nals. At the rest it will be necessary to d absolute longitude by observations of the on. This is a task requiring time and uble, since, to get a sufficiently accurate termination, about 150 observations, extend- g over some months, will be needed. In der that these longtitude observations may multiplied as quickly as possible (and for e determination also of latitude), each party ll take out a large altazimuth instrument, vertical circle, with which azimuths or nith distances of the moon may be observed any part of the heavens. These fine in- uments, as well as the Transit instruments, have been made expressly for the expeditions by Messrs. Troughton and Simms. Such are the modern refinements of observation and theory that it is hoped that, by a combination of altazimuth and transit observations, Green- wich time will ultimately be known at each observatory to within a single second, though, as astronomers well know, to obtain so accu- rate a result as this is a matter of very great difficulty. The determination of latitude will be much simpler, for, in this case, the error, after a week or two's work, is not likely to exceed a few feet.

We come now to the critical and most difficult point of all—that to which all the others are subsidary—namely, the determina- tion of the moment of the planet's first arrival within the sun's disc, or of her departure from it. For the eye-observations of these phe- nomena, each station will be furnished with a telescope of six inches aperture, equatorially mounted, and driven by clockwork with such a speed as to remain steadily fixed on the sun after having been once pointed to it, thus leaving the observer the free use of his hands for other purposes. The famous "Lee" equatorial is one of the number, and will be sent to Alexandria. It might be thought a tolerably simple matter for an observer with a good and powerful telescope to detect the instant of true interior contact of the magnified discs of Venus and the sun. In reality, how- ever, it is very far from easy. Owing to a perplexing phenomenon termed "irradiation," the bright sun appears too large and the dark planet too small. The effect of this is that for several seconds after Venus seems to have completed her ingress she presents a somewhat pear-shaped form, remaining apparently at- tached to the sun's edge by a dark band or ligament, which, from a breadth equal to between 1-10th and 1-20th of the planet's diameter, shrinks to a fine line, and ultimately breaks. Similar appearances, in reversed order, are seen before apparent contact at egress. This ligament is now known generally to astronomers as the "black drop." It is the *crux* of the contact observations, and presents some of the most baffling and for- midable difficulties which mathematicians will have to deal with. By the hitherto accepted theory of irradiation, the instant of breaking or first formation of the black drop, according as ingress or egress is referred to, is sensibly the instant of true contact. But, by experi- ment, it is now found that this theory does not hold good, and that different telescopes give different results under circumstances in all respects the same; and that the differences vary in a most irregular and puzzling manner —though, as a rule, the larger and better

the telescope and the duller the light, the less is the amount of irradiation and the earlier the breaking of the black drop. With the double purpose of investigating these matters and of finding at the same time the "personal equations" of the observers, Sir George Airy devised a model of the transit of Venus, which has been in working order at Greenwich for the last few months. In this, a "heliostat," or revolving mirror, is used to flash the sun's rays through an aparture in a black metal shield towards an observing station 400ft. beyond it, where the telescopes are erected. The edges of this aperture on either side are so constructed as to represent truly the curves of the sun's circumference at those parts where Venus will make her entry and exit, calculated for the given distance of 400ft.; and across the opening a plate of glass, carrying a metal disc, which is similarly proportioned to the size of the planet and placed properly in position with respect to the curves, is made to travel, by attachment to an astronomical clock, with a velocity corresponding to that which Venus will have at the time of Transit. This simple but most ingenious contrivance affords an excellent means of testing the properties of irradiation as exhibited by different telescopes, to different observers, and under varying conditions of sunlight. The mock Venus can be placed in actual contact with the mock sun, or at any number of seconds by the clock before or after contact; or the phases of ingress or egress may be allowed to transpire, just as in the real Transit. The several appearances seen in the telescopes at the observing station can then be registered and compared; they may also be photographed, for comparison of the phenomena imprinted on a photagraph with those witnessed by the eye. A large number of such observations have already been made at Greenwich, by the very men who will ultimately be engaged in the more serious work of the real Transit. It is true that we are dealing only with a short distance, a slightly diminished light, a mock sun, and a flat bit of metal instead of a globular planet surrounded by an atmosphere. Yet it is no less certain that the model exhibits phenomena very closely approximate to the true ones, and that in the hands of Sir George Airy, ably seconded by Captain Tupman, whom he has intrusted with the management of all the details and calculations, this series of experiments will give results of very great value for the accurate reduction of the contact observations.

But the critical observation of the instant of true contact is, fortunately, not the only one which the observer will be able to depend upon. By means of a beautiful apparatus called the "doublet-image micrometer," also the invention of Sir George Airy—which may be briefly described as a four-glass erecting eye piece, one lens of which (the third from the eye) is divided, so that two images of any object may be moved past one another over an angular distance measurable by a micrometer screw—he will be able, during five or six minutes before contact at ingress, or after contact at egress, to determine with accuracy the distances between the fine horns or "cusps" of light intervening between the dark body of Venus and the sun's circumference. Reverting to our former illustration of the crown-piece and round table, if any one will now place the coin just overlapping the edge of the table, he will understand what is meant by the cusps, and will see that, as the coin is gradually moved outwards or inwards, the distance between the cusps is accordingly increased or diminished. The double-image micrometer can also be utilized when Venus is wholly on the sun for measuring the distance between her edge and the near edge of the sun, so long as that distance does not exceed her own diameter. In these two ways, a large number of very good measures of the planet's position on the sun's face will be obtained, irrespectively of the true contact; and as the exact time of each observation will be noted, it will be possible, by comparison of the measurements, to infer the time of contact with great precision from them alone, should this be necessary.

Solar photography will be largely employed during the transit as an auxiliary to the eye-observations, and results of extreme accuracy are anticipated from it. Five magnificent photoheliographs, one to each principal station, have been constructed for the occasion by Mr. Dallmeyer, with such exquisite refinement of scientific care and ingenuity that their optical properties may be pronounced the most perfect yet attained. The photographs taken by them will be free from all distortions and imperfections other than those which might possibly result from unequal contraction of the film, in the wet-collodion process, but which are totally inappreciable in practice, if, indeed, they exist at all. The chymical processes best calculated to produce perfect pictures have also been very carefully considered by Dr. Warren De La Rue, Captain Abney, and other eminent photographers. Such, in short, will be the mathematical precision and sharpness of outlines in these photographs that they will be perfectly available for exact micrometric measurements of the minute and delicate differences of distance and position with which astronomers will be

cerned in their subsequent investigations. ke the principal telescopes just now de- ibed, the photoheliographs are equatorially unted, and carried along by clock-work th the same velocity as the sun. For the ke of popular explanation, they may be said resemble large and powerful telescopes, ted with a camera at the eye-end. Nearly the primary focus of the object-glass is aced an instantaneous exposing shutter, held position by a detent, which acts against a werful spring attached to the lower end of e shutter. A slit across this shutter, dinarily about one-tenth of an inch in readth, can be widened or contracted by an djusting screw, to suit the intensity of the unlight; and, on the release of the detent, momentary flash, darting through this slit s the shutter flies down, paints a four-inch icture of the sun on the sensitive collodion late in a very small fraction of a second of ime. In this way, sun-photographs may be aken with great rapidity at certain stages of the transit, Venus appearing in the pictures as a black spot on the sun's face, about one- eighth of an inch in diameter. But for the yet more rapid portraiture of the planet's changes of position at the critical phases of ingress and egress, use will be made of an ingenious apparatus known by the name of its inventor, M. Janssen. This consists of a device for exposing, at very short intervals, parts only of a rotating collodion plate along its outer edge. The pictures thus taken will be very small, comprising only that bit of the sun's rim across which Venus may be moving. This, however, is all that will be needed just then; and as 30 or 40 of these pictures will be taken in about two minutes, and the instant of each exposure be accurately noted, they will furnish the means of obtaining an exceed- ingly close approximation to the true moment of the breaking of the black drop. For the other stages of the transit, full-sized photo- graphs will obviously be needed, so as to xhibit the sun's centre as a fixed referring- oint for admeasurements. A series of such ctures taken at our southern stations, where e whole transit will be visible, will possess eat value in connexion with the Halleyan ethod of observing the whole duration of enus's passage. They may, indeed, be said amount in principal to a modification of alley's method. For they will register with nsummate accuracy, from widely-severed ations, the position of the chords described the planets centre across the sun's face, for mparison with the positions of those cords determined by the method of durations. hose taken near the middle of the Transit ill also afford a direct measure of the least distances between the centres of Venus and the sun, which is again another modification of the same method. In all these photogra- phic operations it is likely that the dry-plate process will be chiefly employed, on account of its great simplicity and rapidity.

Lastly, it has been proposed by the eminent astronomer Father Secchi, of Rome, to utilize the *exterior* contacts of Venus and the sun, by means of a peculiar adaptation of the spectro- scope, which enables the chromosphere or hy- drogen stratum overlying the sun's photo- sphere to be seen at the same time as the photosphere itself, so that Venus's limb may appear projected on the chromosphere before it reaches the photosphere or ordinary telesco- pic limb of the sun; the planet's approah to, and first exterior contact with, the sun may thus be watched. Supplementary observa- tions of this kind will probably be attempted by Captain Tupman at Honolulu, and by Lord Lindsay at the Mauritius.

There is one excellent feature of the general arrangements which must not be unnoticed. In the history of astronomical expeditions, few mistakes have been made than that of sending out observers deficient in prac- tical knowledge of their work and their instruments. No apprehensions on this score need be felt on the present occasion. In building with their own hands the observa- tory-huts and foundation-piers, as well as in the erection, adjustment, and constant use in the best possible way of the identical instru- ments which they will take with them, and also in the reduction of their observations, the scientific staff have been undergoing a long and complicated drill, the practical value of which it would be difficult to overstate. By means also of the model, they have been systematically exercised in the observation of the phenomena of the Transit, learning what they may expect to see, what precautions to take, and what points to note. In fact, so thoroughly expert will they probably have come, by the time the expeditions start, in the practical details of their work, that, if they are only favoured with clear skies during the momentous hours of the transit, we may count with confidence on entire success.

Nor will they be by any means alone in their interesting task. America and some of the chief States of Europe are making costly and elaborate preparations to co-operate. France will, it is understood, despatch observ- ing parties to St. Paul Island, Amsterdam Is- land, Campbell Island, and Marquesas Islands, in the southern hemisphere, and to Pekin and Yokohama, in the northern, and will also pro- vide some secondary stations in one or two of her Colonies. Germany proposes to occupy

Auckland Island, Macdonald Island, Bluff Harbour (New Zealand), and Mauritius in the south, and in the north a station in China or Japan, and a photographic station in Persia, on the line of the Indian telegraph. Of American plans little certain is yet known, but they will probably comprise the establishment of three or four stations — one of them at Macdonald Island—in the southern hemisphere, and as many in the northern. And Russia, strong in the advantage of having an immense adjacent tract of her own territory favourable for observations of the Transit, will equip, though on a more moderate scale than the other countries, no fewer than 27 stations between Odessa and Japan, 15 of which, distributed over Western Siberia and Eastern Russia, and round the Black and Caspian Seas, are well suited for Delislean observations of the retarded egress, while the rest are Halleyan stations, situated chiefly in Eastern Siberia and Tartary. At the stations we have above enumerated, eye-observations of contact photography applied in two or three different ways, and the "direct" method of measuring with a heliometer the distances between the centres of Venus and the sun will be variously employed. Lastly, British India will be represented by a photographic station in the Punjab, under the charge of Lieutenant-Colonel Tennant, R.E.; Lord Lindsay, with the liberality in scientific matters for which he is distinguished, will take an admirably equipped private expedition to Mauritius; and our Colonies and Colonial Observatories are preparing to co-operate at suitable points. Altogether, there will be at least 70 or 80 stations, scattered over the illuminated side of the earth, from which, between the hours of about half-past 1 and half-past 6, Greenwich time, on the morning of the 9th of December, a small army of astronomers will be anxiously scanning, measuring, and photographing the movements over the sun's face of the little black spot which is to afford us a solution of one of the sublimest problems of the universe.

It will be interesting to note, finally, what is likely to be the ultimate issue of this grand combined attack upon the problem of the sun's distance—or, to speak technically, its "equatorial horizontal parallax," which is simply an astronomer's expression for the greatest angle which would be subtended by the earth's equatorial radius to an observer at the distance of the sun's centre, whatever that distance may be taken to be. Without enumerating the eight or ten values of this solar parallax which have been obtained by modern astronomers, by various subtle and refined modes of theory, observation, and experiment, it will be enough to say that the most trustworthy determ tions give an average value of about 8·92 s for the parallactic angle, corresponding to s 91,480,000 miles from the sun's distanc with an uncertainty of ·032 secs., or, in ro numbers, 300,000 miles. The Transit Venus may not be the means of altering quantity (8·92 secs.) by any large amo but it will be of the utmost utility a crucical test of previous results, being the o direct geometrical solution of the probl Taking into account all probable errors longitude, local time, photographic and cont observations, it may be assumed, on a by means sanguine estimate, that the existi uncertainty will be reduced to one-third of present amount, or to ·01 secs.; but it is from unlikely that the probable residual er will be no more than one-half of the latt quantity—that is to say, our distance fr the sun will probably have been ascertain within 50,000 miles, or about 1-1800th p of its whole amount. Of the higher scienti advantages we need hardly speak. But, f the information of those who would inquire to its direct practical uses, it may be as we to explain that an accurate knowledge of t sun's distance is essential for the perfecting the lunar and planetary tables, and therefo of the science of navigation, as well as f many other matters of practical importanc such as finding the true longitudes of plac on the earth's surface, which depend on t accuracy of the Lunar Theory.

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Letters to the Editor.

All letters to be addressed to the Editor, at the Institute, 35, Northampton Square, E.C.

ORIGINAL INVENTIONS.

To the Editor of the HOROLOGICAL JOURNAL.

SIR,—An inventor who boldly invites the critics to meet him for the purpose of examining his invention thereby demonstrates his conscientious belief in the originality of his work. But it is disheartening to find at the meeting several gentlemen well qualified, by practical experience and technical knowledge, to act as critics, and—prejudice apart—to pronounce opinions as to the originality and, what is of far more consequence to the trade, and, perhaps, to the inventor, the practical usefulness of his method, who, upon examination aver that there is in it nothing useful! nothing new! It had been done by several of them and by others; models of the same thing, made years, ago are lying *perdu* in "little boxes." Inventors are not prone to proclaim their failures until, curiously, somebody springs up with an imitation.

The Institute possesses copies of all the patent specifications of Great Britain which contain matters relating in any way to Horology. The value of this convenience to inventors for the purposes of reference cannot be over-estimated. I do not know whether others than members have the privilege of access to them. Attached to the Institute is a museum, and the mouthpiece of the trade is the *Journal* of the Institute. If the models in the little boxes, presumed to be of little intrinsic value, had been deposited in the museum open to the inspection of the members, or if the several inventors had described in the *Journal* the various means they had employed to effect their object, much time in working out ideas and expense in constructing models and patent fees, might have been saved, not only in this instance, but if we had not had the meeting referred to, which was reported in the *Journal*, to act as a guide and as a warning, in many more similar cases, which might have followed. The obvious intention of this letter may be a sufficient inducement for you to publish it.

I am yours, &c.,

W. S. HARRISON.

SIR,—Permit me to lay before your society the following difficulty that I observed of one pendulum influencing another when in close vicinity. I have applied at the Royal Observatory; the case has not been observed there, nor can I find any published explanation on this subject, except when pendulums are vibrating in the same plane.

How the disturbance came to be observed:—The Rev. Archdeacon Stock, who has charge of the Wellington time-ball transit apparatus in New Zealand, having no mechanical tastes, requested me to put up the apparatus for him. I prefer cleaning the clocks myself to allowing them to go into the clockmaker's hands. I had the dropping clock out for cleaning, when Mr. Stock observed that the pendulum was vibrating (which I found to be the case) somewhat less than half the usual beat. After some time, say a quarter to half an hour, it occurred to me that the pendulum ought to be at rest (from the time elapsed since taking the works out of the case), and that the continued motion must result from the influence of the pendulum of the astronomical clock. I found the pendulum still vibrating about the same. I then placed it at rest, carefully closing the case. In about a quarter of an hour I found the pendulum vibrating about one quarter of an inch from the perpendicular. I tried it a second time, with the same result. I afterwards found that the light weight and wooden pendulum of the dropping clock influenced the mercury weight and steel pendulum of the astronomical clock, but only through about half the distance. Having only one astronomical, I did not dare to go into experiment to find the cause.

It has been observed that after as carefully as possible correcting the height of the mercury for temperature there was a varying rate independent of meteorological causes. Might not the sympathy of the pendulum be the cause?

When placing the clocks I was aware that two pendulums vibrating in the same plane would affect one another, so I placed them so as to vibrate at right angles.

The pedestal is of brick, set in cement some two feet on the earth, composed of broken sandstone, the interstice filled with a sandy clay. There are two stone slabs on top of angular brick work, with wooden framework (separate to both clocks) of three inch square scantling, and braced with iron screw rods.

Any information will be thankfully received.

QUERY.—How far would it be necessary to place the clocks apart to prevent one clock affecting the other, because for convenience they should stand together?

I am, sir, yours truly,

JOHN REBBELL.

Auckland Island, Macdonald Island, Bluff Harbour (New Zealand), and Mauritius in the south, and in the north a station in China or Japan, and a photographic station in Persia, on the line of the Indian telegraph. Of American plans little certain is yet known, but they will probably comprise the establishment of three or four stations — one of them at Macdonald Island—in the southern hemisphere, and as many in the northern. And Russia, strong in the advantage of having an immense adjacent tract of her own territory favourable for observations of the Transit, will equip, though on a more moderate scale than the other countries, no fewer than 27 stations between Odessa and Japan, 15 of which, distributed over Western Siberia and Eastern Russia, and round the Black and Caspian Seas, are well suited for Delislean observations of the retarded egress, while the rest are Halleyan stations, situated chiefly in Eastern Siberia and Tartary. At the stations we have above enumerated, eye-observations of contact photography applied in two or three different ways, and the "direct" method of measuring with a heliometer the distances between the centres of Venus and the sun will be variously employed. Lastly, British India will be represented by a photographic station in the Punjab, under the charge of Lieutenant-Colonel Tennant, R.E.; Lord Lindsay, with the liberality in scientific matters for which he is distinguished, will take an admirably equipped private expedition to Mauritius; and our Colonies and Colonial Observatories are preparing to co-operate at suitable points. Altogether, there will be at least 70 or 80 stations, scattered over the illuminated side of the earth, from which, between the hours of about half-past 1 and half-past 6, Greenwich time, on the morning of the 9th of December, a small army of astronomers will be anxiously scanning, measuring, and photographing the movements over the sun's face of the little black spot which is to afford us a solution of one of the sublimest problems of the universe.

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Horological Institute.

LIST OF NEW MEMBERS.

C., 114, High-street, Sunderland.
—, Watch Maker, Bourk-street,
ourne.
Geo., Watch Maker, Tabernacle-
e, E.C.
s, Wm., Watch Maker and Jeweller,
ch-street, Saffron Walden.
ge, James, Watch Manufacturer, 8,
Lion-street, E.C.
, Richard Edward, Watch and Clock
r, Eastwood, Nottingham.
—, Watch Maker, Carlton-place,
n.
George, Watch Maker, Mansfield.
—, Escapement Maker, Stanford-
Tottenham, N.
T., 16, Cottage-lane, New Charles-
, City-road, E.C.
gh, Watch Maker, Melbourne.
John T., 38, John-street, Glasgow.
—, 169, Bloomsbury-street, Bir-
ham.
J., Jeweller, Upperhead-row, Leeds.
. Makepiece, Watch and Clock
r, 1, High-street, Weston-Super-
.
–, Watch Manufacturer, Reigate.
H., 28, Market-square, Lisburne,
nd.
Lever Escapement Maker, 35, Grove-
Holloway, N.
oy, & Fils, Watch Manufacturers,
va.
thur, Watch Manufacter, 41, Corn-

J., 21, St. John's-square, E.C.
., Defiance, Ohio, U.S.A.
Robert, West Shandon, Dumbarton-

Henry A., Watch Maker, 229, West
more-street, Baltimore, Mary nd,
A.
Wm., 8, Vincent-terrace, Duncan-
ce, Islington, N.
Gustave, Watch Maker, 10, Rhyl-
t, Maldon-road, Kentish Town, N.W.
bez, 86, Church-street, Croydon.
g, M., Watch Material Dealer,
s.
harles, Watch Maker, 130, Gray's
road, W.C.
Geo., Watch Maker, Ipswich-street,
market, Suffolk.
k, 143, Mill-street, Crewe.
H., 10, Market-street, Burnley,
ashire.

To Correspondents.

R. Gourlay, Melbourne, Australia.—*The subscription is 12s. per year. The best, indeed the only, work obtainable is the back volumes of our Journal.*

Is there anything which will effectually destroy magnetism in the steel parts of a clock or watch except passing them through the fire ?—MAK.

Will any of your correspondents oblige by given the entire method of polishing watch wheels, together with the tools, I am able to gloss and face a pinion and will doubtless be able to accomplish wheels, should I but get the necessary information.—P. E.

SIDEREAL TIME OF THE SUN'S SEMIDIAMETER PASSING THE MERIDIAN OF GREENWICH, AND EQUATION OF TIME TABLE.—August, 1874.

Day of the Week.	Day of the Month	Sidereal time of the Semidiam passing the Meridian.*		Equation of Time *to be subt. from* / *added to* Apparent Time.		Difference for One Hour
		M.	S.	M.	S.	S.
Sat	1	1	6·63	6	2·58	0·149
Sun	2	1	6·55	5	58·70	0·174
Mon	3	1	6·46	5	54·24	0·198
Tues	4	1	6·37	5	49·19	0·222
Wed	5	1	6·29	5	43·57	0·246
Thurs ..	6	1	6·20	5	37·38	0·270
Fri	7	1	6·11	5	30·62	0·294
Sat	8	1	6·03	5	23·29	0·318
Sun	9	1	5·95	5	15·38	0·341
Mon	10	1	5·86	5	6·91	0·365
Tues	11	1	5·78	4	57·88	0·388
Wed	12	1	5·70	4	48·28	0·412
Thurs ..	13	1	5·62	4	38·12	0·435
Fri	14	1	5·54	4	27·40	0·458
Sat	15	1	5·46	4	16·13	0·481
Sun	16	1	5·38	4	4·33	0·503
Mon	17	1	5·31	3	51·99	0·525
Tues	18	1	5·24	3	39·13	0·547
Wed	19	1	5·16	3	25·76	0.568
Thurs ..	20	1	5·09	3	11·89	0·588
Fri	21	1	5·02	2	57·53	0·608
Sat	22	1	4·96	2	42·70	0·628
Sun	23	1	4·89	2	27·40	0·647
Mon	24	1	4·83	2	11·66	0·665
Tues	25	1	4·77	1	55·48	0·683
Wed	26	1	4·71	1	38·89	0·700
Thurs ..	27	1	4·66	1	21·89	0·716
Fri	28	1	4·60	1	4·52	0·731
Sat	29	1	4·55	0	46·79	0·746
Sun	30	1	4·50	0	28·73	0·759
Mon	31	1	4·45	0	10·36	0·772

* *Mean* Time of the Semidiameter passing may be found by subtracting 0s·18 from the *Sidereal* time.

INDEX TO VOLUME XVI.

END OF VOLUME XVI.

R. J. Donovan, Printer, 260a, Whitechapel Road, E.

THE

OROLOGICAL JOURNAL:

THE

Special Organ

OF THE

BRITISH HOROLOGICAL INSTITUTE.

VOLUME XVII.

LONDON:

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1875.

UST 1, 1875.

The Horological Journal.

VOLUME XVII.

SEPTEMBER 1, 1874.

British Horological Institute.

THE ESSAYS ON THE COMPENSATION BALANCE.

REPORT OF THE ADJUDICATORS.

To the Council of the British Horological Institute.

AVING examined the essays sent to compete for the prize of fifty pounds, offered by the ght Honourable the Baroness Burdett Coutts to the writer of the best Essay on the Compensation Balance and its adjustments in chronometers and watches," we con ler the essay bearing the motto "Scire tuum nihil est, nisi te scire hoc sciat alter" st fulfils the conditions. We therefore award the prize to the writer of that essay.

Signed, G. B. AIRY. C. WHEATSTONE. A. P. WALSH.

The foregoing report having been read at a Council meeting, held the 4th August, 74, the Chairman opened the envelope bearing the motto selected by the judges, and clared the writer of the essay to be Mr. W. B. Crisp, of 174, St. John Street Road.

While we congratulate Mr. Crisp on the high honour he has attained, we must not iit to express our appreciation of the spirit of emulation shown by the other gentlemen 10 responded to the invitation of the Council to compete for the prize. Fully recog- zing the great amount of thought and labour involved in writing a competitive essay on a technical subject, we shall be glad (with the permission of the authors) to blish several of the essays, as space permits.

ANNUAL GENERAL MEETING.

The Annual Meeting of the Members for the Election of Officers and the transacti of ordinary business, was held at the Institute, on Tuesday, August 11th, Mr. E. J Johnson, F.R.A.S. (vice-president), presiding.

After reading the minutes of the previous general meeting, the secretary read tl report and balance sheet, as follows:—

Report for the half-year ended 30th June, 1874.

"The Council have much pleasure in submitting a statement shewing the continued financial success of the Institute. The half year closed with a balance of £25 in favour of the Institute, which is satisfactory, bearing in mind that the aim of the Council has ever been the furtherance of the objects for which the Institute was established rather than the accumulation of funds.

"The Institute generally will be glad of an opportunity of acknowledging the exertions of the gentlemen who acted as a committee for arranging the exhibition, and who have just concluded their labours by clearing up the outstanding accounts connected therewith. The distribution of the prizes awarded at the exhibition by the hands of the Lord Mayor, at the Mansion House, must be held to be an acknowledgment of the value and position of the Institute.

"The drawing-master reports that although fair progress has been made, the attendance has not been so regular as could have been desired, a result perhaps inseparable from classes where the majority of the pupils work at their trades during the day. The Council regret that the advantages offered, which really are considerable, are not so highly appreciated by the students, as by the older members of the trade. The future self-interest of the pupils, the Counc feel, depends on their availing themselves the opportunity which the Institute affords.

"The essays sent in to compete for th prize offered by the Right Honourable th Baroness Burdett-Coutts, to the writer the best essay on the compensation balanc are still under the consideration of th judges, whose report is daily expected the Council.

"The Goldsmiths' Company continue furnish annually their fund in furtheran of our art, affording the Council this oppo tunity of acknowledging the same wi thanks.

"The Council have to thank the Deput Master of the Mint, for his courtesy in a ceding to the request of the Council granting admission to a considerable num ber of the Members to inspect the variou processes at the Mint.

"Mr. Schoof's paper on the lever escape ment, was read before a very full assem blage of the members, comprising some our most eminent watchmakers, and elicite a lively conversation on the various point raised.

"Twenty-eight new members have bee elected during the half-year.—By order the Council,

"(Signed) F. J. Britten, *Secretary*."

Balance Sheet for the Half-Year ended 30th June, 1874.

Dr.	£	*s.*	*d.*
To Balance in Treasurer's hands last Audit	19	11	1
,, do. do. Building Fd.	51	5	0
,, Donation (Goldsmiths' Company) ..	50	0	0
,, Subscriptions	76	13	0
,, Sales of Journals	45	7	2
,, Advertisements	37	15	6
,, Drawing Class Fees	3	5	0
,, Sundries	5	3	0
,, Contributions to Exhibition Fund ..	37	0	0
,, Six Months' Interest of Building Fd.	1	5	7
	£327	5	4

Cr.	£	*s.*	*d.*
By Rent and Taxes	40	11	1
,, Salaries, Wages, and Commissions ..	56	3	
,, Journal Expenses	70	6	
,, Stationery, Stamps, &c.	41	13	
,, House Expenses	5	11	1
,, Printing	6	12	
,, Repairing Regulator	1	15	
,, Sundries	2	9	
,, Exhibition Expenses	61	4	
	£249	2	
Balance:			
Cash in Treasurer's hands	25	12	
,, ,, ,, Building Fund	52	10	
	£327	5	

We have Examined the above, together with the Books and Vouchers, and certify the same to be correct, this 16th day of July, 1874,

(Signed) James Pyott. C. H. Hawkins. } *Auditors.*

THE CHAIRMAN, in moving the adoption of the Report, said:—I am sure you will not call upon me to give an assurance of the lively interest I take in the Institute, and the lively gratification it gives me in congratulating you on the advancing prosperity of the Institute. There are some little points which, as matter more of feeling than fact, I could take exception to in the Report of your Council, but I may let them pass in view of the general sunshine which seems to mark your progress. One particular is the state of your finances. I don't know the day when the sum in the hands of your treasurer amounted to over £5. I think I may call upon Mr. Jackson to say the state of the funds was good in the early days, but there was not the power to use them. It is quite true the character of this institution is such, that one would imagine we should have had too great a rush for our means, rather than too small a constituency. But it is plain the progress made is like that of the oak, it is slow, but it shows itself now to be composed of solid timber. Amongst other gratifying circumstances on which I wish to congratulate you heartily, is the steady notice into which the Council are leading the Institute itself. Nothing can be more gratifying than the recognition by public companies, such as the Goldsmiths' Company, by whom the notice must be looked upon pre-eminently to their honour, inseparable as are the institutions themselves. A watch can no more be used without the case than the case can be used without the watch. They are rich enough to be generous, let us hope they will be generous enough to make themselves rich in the good wishes of others. Another mark of progress is the support of the Baroness Burdett-Coutts. I may congratulate Mr. Jones, the indefatigable vice-president—who, I believe, was instrumental in introducing the Institute to the notice of of that lady—upon the success which has in this case attended his efforts on our behalf. May he go on to the end of his time so excellent a vice-president; without his services I don't know what the Institute would have done. (Hear, hear.) Mr. Klaftenberger cannot move about much now on account of an infirmity in his feet, but we are grateful to him for past services. I am a valetudinarian, it is little I can do. I thank you for retaining me the honour, though now an ornamental vice-president only. The time was when I could labour, but you must take, as I do, the memory of the days when we worked together. With regard to our president, I must congratulate him on the acquisition of new honours. You could not have made a better selection; he has a thorough knowledge of the usefulness to which horology leads. No better president, I think, could have been found through the length and breadth of the land. With regard to public recognition of your standing I may remark on those visits you make to such institutions as the Royal Observatory and the Mint. It is an excellent idea. With regard to the Journal, I must say we owe much to those editors who have sacrificed their time in order to make it worthy of the Institute. I think never has the Journal had such a place in public estimation as it holds to-day. The evidence of this is to be found in the increased sale. Whatever sells well, you may depend upon it, does well. With regard to the members, I don't know, the secretary not having supplied me with numbers; but as he and the Council have not announced any falling off, through what I saw must one day take place—the raising of subscriptions—I think the Council may congratulate themselves on taking a step in the right direction. The energy of your secretary, I think, deserves well at the hands of your Institution. With regard to the endowment, one is hardly in a position to make a remark about it at present, although I thought it was premature to bury treasure under any such notion as that of building, this is a distinct affair, the legacy, of Mr. Knight was, I think, left as a distinct endowment. In consequence of that, I think the wishes of those who in their will explain clearly what they desire, should be almost sacred. Therefore the expressed wish of Mr. Knight should be adhered to in the hope that the fund may be increased, and his wishes realised. On the whole I congratulate you on the prosperous state of things. I understand our old friend, Mr. Crisp, has arrived at the age of rejuvenescence; he has written a paper on the compensation balance, I hope amongst other compensations he will get sufficient compensation for his paper. I observe and do know that every half-year becomes one of promise, because in all material items the half-year shows an increase. Institutions, like men, never stand still; whatever ceases to advance commences to retrograde. Whatever may be the opportunity or prospects of the Institute, try to do something you have not done before. I have great pleasure in moving the adoption of this Report.

MR. JACKSON had great pleasure in seconding this. He did not believe he could add anything to the remarks of their worthy vice-president, whom he was pleased to see among them after so long an absence. He hoped he would not be away so long again.

With regard to the endowment fund, the chairman seemed to have some doubt as to the existence of the fund intact. It existed as it always had done, in the hands of trustees. He thought it necessary to say this for the satisfaction of those who were not aware of it. He trusted it would be the beginning of a fund which would be raised, either by bequest, or—what was better—donations, for the purpose. He was sure the interests of the Institute could be no better served than in this way. It lessened the labours of a secretary, whose labours were heavy, especially as that society having lost the novelty which it held, the secretary was deprived of that help which in former years was necessary. Some gentlemen opposed endowments because they were abused, but that was a remote anticipation in their history. They had not the immediate prospect of an endowment. It was gratifying also to find, though there had been some very heavy expenses connected with the exhibition of last year, a better balance had been obtained than had been the case for a long time. These expenses had been met by the distinguished liberality of the Baroness Burdett-Coutts, who had liberally assisted them. He was of opinion that they needed the co-operation of the members with their excellent secretary. Their greatest hope for the future was in the persevering attention of their secretary, to whom they were much indebted.

Mr. BICKLEY, in supporting the motion for the adoption of the Report, referred to the remarks of the president at the meeting for the distribution of prizes held at the Mansion House, which he said had astonished him. The president had spoken as though the Council had given exclusive attention to mere finger work, the facing of pinions, and polishing of screws, in the distribution of prizes. In the first place, he would say that the Council offered and gave no prizes for such work, though they were mentioned in the Report. Then the president had said prize essays were useless and ridiculed one of the last, perhaps not without cause. He, however, said nothing about the essay of Mr. Grossmann, which really the text book on lever escapements. They could not be always alike good. If these essays on isochronism were not as good as the first, that was no reason why he should have spoken as he did of the principle. He (Mr. Bickley) was very sorry the remarks should have been made. The Council had worked [illegible]d, and the result was an exhibition which, [illegible]gh small, had been favourably noticed [illegible]e press, and by the trade; and he thought it was too bad of their president to tell the working men who had won prizes, they were receiving them for that which was not worth twopence. That meeting would have done them good, but people went away disgusted, because they found the Council and the president were not working together. He thought they had some little claim on their president, and when he came to a meeting like that, he should be careful not to say things which would lead people to think they were not working harmoniously together. He felt himself exceedingly little on that occasion, and though he might not have the gift to speak on the subject as their president did, he felt quite as full of the subject as that gentleman could be. Passing from that, he might say he felt satisfied of the prospects of the Institute, and the progress it made. They were out of debt, and had something to the good, and with steady application they might achieve the position he hoped the Institute would one day occupy.

Mr. JONES, in reference to the remarks of the previous speaker, thought that gentleman had put too serious a face upon the matter. Their president had made some hard remarks, but when he came to consider what he had said and gave his own report of his speech, it was much more temperate than that to which they had listened at the Mansion House. Many of his remarks on their work would have given no room for cavil. He, however, had an idea that they had gone in clock-making far enough, or as far as they could go under the old principles, and it was necessary for perfection some new thought should be brought forward in originality of character and principle. He supposed it was in other words an application of that to their exhibition which caused him to speak a little unwisely at the meeting in question. He supposed if he had considered the matter he would have spoken more guardedly. That being the case, he thought there was little to find fault with. With reference to prize essays, Sir Edmund Beckett was evidently thinking of those he and other young men used to write at Cambridge, which their president evidently thought were not worth much, and with which it was not at all likely their essays would compare. (Laughter.) They should, then, forget any strokes they might have received under the impression they were intended to lead them to the development of something new, either in cheapness of work or the development of new ideas. They should congratulate the president on the acquisition of a position of honour. There was

nother point to which he should allude. Without the supplementary income from dinners they used to have they had a surplus n hand, which was a matter for congratulation, as those dinners were to his mind a kind of shearing time, although at the same ime they missed the social intercourse they afforded. That Institute should be the means of bringing honour to those entitled to honour, and for this reason they should keep up its *prestige*. The Institute was fulfilling a great purpose, and it must be kept alive, because education was so advancing that boys would now appreciate, as they never had appreciated before, the advantages the Institute had offered of acquiring a thorough knowledge of the principles of Horology. In conclusion, he was pleased to know everything was going on well, and particularly pleased to see one who had done so much in that organisation as their chairman, present that evening.

Mr. Glasgow was of opinion that if they were to work harmoniously together, they must not allow the valuable work of such men as Mr. Bickley to be slighted, even by their president, who had condemned what he had not seen. Mr. Jones had said the president's wish was to give them an idea. The idea was that of cheapening watches in competition to an American watch company; but if he thought the British Horological Institute existed merely for the purpose of cheapening watches, he would at once leave it. He thought their object was to make the watches in Clerkenwell an example to others. There were plenty of persons trying to cheapen watches. He did not see why the labours of a few men in connection with the Institute should be sneered at by their president, or some one who might take his place. These gentlemen had hoped the Institute would be enabled, as the result of the meeting, to occupy the position to which it was entitled, but they were disappointed. If their president had come to the Institute and argued the question of American watches, they would be found ready with argument to answer him. The suggestion that Mr. Denison should be invited to give them a lecture on large clocks, came from him in admiration of their president's undoubted talents, but he (Mr. Glasgow) felt that he should have been wanting in his duty if he had refrained from making the remarks he had made that evening.

The Chairman then put the motion for the adoption of the Report and Balance Sheet, which was carried unamiously.

Mr. Jackson moved the re-election of the president, Sir Edmund Beckett, Bart., LL.D., Q.C., F.R.A.S. Referring to the remarks of that gentleman at the Mansion House, he said he thought he should have expressed his views to the committee privately, if he held a strong opinion contrary to their own as to anything they had done with a view to improve the trade. As a matter of respect to him, and the views which he believed he conscientiously held on that occasion, however much they might differ from him, they might find in his remarks something of good to them. He did not intend to justify all that gentleman's remarks, but they might learn something from them. They were entitled to serious consideration, their president being willing to do his best to promote the interests of the Institute. He had much pleasure in moving the reelection of that gentleman.

Mr. Evans, in seconding, said he endorsed all that had been said by the previous speaker.

Mr. Isaac, in supporting the motion, said he had been struck with the remarks of their president, on the occasion in question, but thought the suggestions were thrown out for their good, and as such should be carefully considered.

The resolution having been carried,

The re election of C. J. Klaftenberger, E. D. Johnson, F.R.A.S., Jno. Jones, F.R.G.S., as the vice-presidents was then moved by Mr. Glasgow, seconded by Mr. Isaac, and carried.

The Chairman expressed himself pleased that he retained the confidence of the members. With reference to the remarks of their president, he would remind them that "Sweet are the uses of adversity." He had too large a capacity in connection with the scientific portion of their art not to be a good teacher. There could be no doubt they were too proud of fine workmanship, but they must remember the most excellent workmanship was but the embodiment of the principles brought out by a machine. In Denison's gravity escapement, this was clearly shown. In that escapement they had a principle similar to that which was marked by the change from the vertical to the detached escapement, in whatever form it might exist. The change only in the principle was such in its results that he held the worst detached escapement that was made would be even a better timekeeper than the best vertical escapement ever produced. (No.) He begged to thank them for his re-election.

Mr. Jones also returned thanks for the confidence reposed in him by his re-election to the post of vice-president, and expressed

his regret that he had been prevented by the state of his health from doing the work he used to do in connection with the Institute, and referred briefly to the earnestness with which many of the earlier members had worked.

On the motion of the chairman, Mr. Jackson was re-elected treasurer, and in returning thanks said he felt the Institute would not suffer if some one were elected in his stead. He had been treasurer four or five times as long as his predecessor.

Mr. Jackson moved that the Council for the ensuing year do consist of the following gentlemen :—

C. Bacon, 37, Gerrard-st., Islington.
G. Barter, 41, Wilmington-sq., W.C.
H. Bickley, 33, Half-Moon Crescent, Barnsbury.
W. B. Crisp, 174, St. John-street-road.
J. Evans, 89, Mount-street, Grosvenor-square.
D. Glasgow, 20, Myddleton-square.
J. J. Hall, F.M.S., 1, Albion-villas, Grove-road, Windsor.
G. Hollister, 37, Davies-street, Berkeley-square.
M. Immisch, 211, Regent-street, W.
H. P. Isaac, 147, Liverpool-road, N.
C. Killick, 154, Packington-street.
V. Kullberg, 105, Liverpool-road.
C. Lange, 99, Strand.
J. A. Lund, Cornhill.
G. Mayer, 33, Charlotte-street, E.
T. Mercer, 161, Goswell-road.
G. Morton, 31, Hanover-street, N.
T. Nelson, 31, Halton-road, Canonbury.
J. Penn, 31, Queen's-road, Peckham, S.E.
E. S. Perrett, 23, Abingdon-street, S.W.
G. Prickett, 5, Corporation-row.
W. H. Prosser, 88, Bartholomew-road, N.W.
W. G. Schoof, 9, Lower Ashby-street.
A. Smythson, 1a, Harper-street, Red Lion-sq. W.C.
R. Strachan, F.M.S., 11, Offord-road, Barnsbury.
A. Thickbroom, 6, Spencer-street.
A. P. Walsh, 5, George-st., Euston-road.
T. J. Willis, 10, Rydon-crescent.

Mr. Bickley said, in reference to the nomination of the Council, he thought it a pity they should continue year after year to nominate on the Council persons who never came into that room. He thought the number also was too great. He was proceeding, but was reminded by the chairman that to alter the number, a revision of the laws would be necessary.

The Chairman having announced that Mr. Hall declined re-election, his name was withdrawn, and the list having been seconded by Mr. Jones, adopted,

The re-election of Mr. James Pyott and Mr. C. H. Hawkins, as auditors, was moved by Mr. Isaac; that gentleman remarking at the same time that he had seen the same members elected several times, and he thought it would be advisible to ascertain the names of any other gentlemen who might be willing to fill the office.

Mr. Jones seconded, remarking that the suggestion of Mr. Isaac was a good one in principle, and might be acted upon another time.

The resolution was carried.

Mr. Jones moved a vote of thanks to the President (Sir Edmund Beckett), and "that they congratulate him on the social position he had inherited." His advancement would prove their advancement also.

Mr. Crisp seconded this, and it was carried *nem. con.*

Mr. Glasgow begged to move a vote of thanks to the vice-presidents, without whose co-operation the labours of the members would be of very little value. The chairman, as they knew, had done much, as had also Mr. Jones. Mr. Klaftenberger must also be thanked for what he had done. He would be glad if the vice-presidents would always put in an appearance when they had a public meeting of the Institute.

The resolution, having been duly seconded, was carried.

On the motion of Mr. Mackintosh, seconded by the chairman, a vote of thanks to the Council was passed and acknowledged by—

Mr. Bickley, who said he had been much pleased to be present at the meetings of the Council. He thought if gentlemen came to those meetings, and made themselves intimately acquainted with the working of the Institute, they would advocate its cause with greater zeal outside. He hoped their efforts in the future might be as successful as those in the past; and saw no reason to doubt that such would be the case. (Applause.)

Mr. Jackson moved, and Mr. Isaac seconded, a vote of thanks to the Auditors, which was carried unanimously.

The Chairman, in acknowledging the compliment, thanked them for himself, and observed he was sorry to say most of the work fell upon Mr. Jones, whom he hoped would enjoy all the blessings of continued activity, and be able to thank them for many votes of thanks.

A vote of thanks was accorded to the Secretary (Mr. Britten), on the motion of chairman, seconded by Mr. Jackson, who eulogised the manner in which Mr. Britten performed the duties of secretary, editor, and teacher of the classes.

The services of the Press and the Chairman having been acknowledged, the proceedings terminated.

The attention of members is directed to an advertisement in this number, concerning a visit to the Royal Arsenal, Woolwich, which has been arranged for Tuesday, September 15th.

PRIZE ESSAY ON THE COMPENSATION BALANCE, AND ITS ADJUSTMENTS IN CHRONOMETERS AND WATCHES.

(THE BARONESS BURDETT COUTTS'S PRIZE,)

By W. B. CRISP.

"Scire tuum nihil est, nisi te scire hoc sciat alter."

INTRODUCTION.

In this Essay on the Compensation Balance it is my intention to write in as plain a manner as possible, avoiding all mathematical problems, signs, and paradoxes, and to endeavour to write so that it may be understood, not only by the theoretical mathematician, but by the workman and practical mechanic. I am well aware that it is a task — a highly scientific proposition to solve — and also that it is a problem which has engaged the attention, not only of the most practical chronometer and watchmakers of this country, but watchmakers of France, Holland, Sweden, and the United States of America. It has also engaged the attention of astronomers, mathematicians, and the greatest mechanicians of the age; and more particularly so during the last fifty years. And yet in this balance of ordinary construction there is an unconquerable error existing in the middle temperature; it appears so simple that many cannot conceive why we should not have a compensation balance perfect in itself, one answering regularly and truly to all variations of temperature, be they high, low, or intermediate, that all chronometers are exposed to.

It will be my duty in this Essay to describe the practical method of making the compensation balance, and also the mode of adjusting it, and to determine its error.

It may be as well for me here to remark that nearly a century has passed since the Government of this country offered a large reward for the construction of a time-piece which should, by its good performance, show the mean time at Greenwich, wherever it was taken, with sufficient accuracy to enable the longitude to be determined, within certain limits. As is well known, Harrison gained the principal prize, but smaller amounts were also awarded to Mudge, Arnold, Earnshaw, and others, for their successive improvements. The general form of movement, escapement, and balance in use at the present day is that invented and made by Earnshaw, of whom it will be my duty to speak more fully at the proper time and place.

The great difficulty we have to contend with lies in the pendulum spring, and in the balance to which it has to be applied. The pendulum spring loses so much of its elastic force by heat, and, on the contrary, its elastic force is increased by cold, that a watch or chronometer with an uncompensated balance will lose in heat, and gain in cold, to a very large extent. Thus, then, this balance of ordinary construction is called a compensation balance, from its action in compensating for the effect of temperature, in altering the rate of going in the chronometer by the variations of the pendulum-spring. The balance acts in the following manner:—It is so made that, at the same time that the spring loses its strength or force by heat, its outer rim, with the weights borne upon it, is forced towards the centre of motion, this giving the spring less work to do, and compensating for the defect. For a long time this was thought to be sufficient, but close observation eventually showed that extremes of heat or cold would cause an otherwise well rated chronometer to lose upon its rate. This is greatly due to the form of the balance, and, up to the present time, no balance has been made, running, as it were, perfectly in unison, and so exactly compensating for the variations of the pendulum spring, that we could say, "This balance is so perfect in its construction that, as the spring elongates or loses its elastic force by heat, or, on the other hand, as the spring's elastic force is increased by cold, that this balance will compensate for all

degrees of temperature, be they high, low, or intermediate."

It will be unnecessary for me to describe any of the balances in use before the time of Arnold and Earnshaw. The latter must be looked upon with great respect, and every chronometer maker must feel that his genius has never been surpassed, because of this great fact:—His escapements and balances are in use to the present day, and they are made in the same manner as he made them. Many ingenious workmen have toiled in vain to improve the escapement, but time has shown how soon they laboured to no purpose, and all returned to the grand principles laid down by Earnshaw, whose escapements are so perfect that they now stand, as it were, masterpieces of the past, and models for the future. Arnold, on the contrary, abandoned both his escapements and balances, manufacturing chronometers on Earnshaw's principle during the lifetime of this inventor. Arnold not only felt convinced of the superiority of the construction of those balances and escapements, but made them, and applied them to his chronometers, which at that time were telling their own tales. His escapements were cutting, and failing in every direction; his balances were so soft, and so easily bent, it was almost impossible to clean them without putting them out of figure, so much so as to seriously alter the rates of his chronometers, and they are now spoken of as a relic of the past. But Arnold was superior to Earnshaw in the making of his pendulum springs, and was also the first to harden and temper them, and to make them of a cylindrical or helical shape, obtaining his isochronism by length and angles of inflection. He also made springs with one end of the block spiralled down for the first turn of the spring, which was fixed in a movable stud to meet the curve of the spring, which was fastened by two screws. Earnshaw was at that time obtaining his isochronism by tapering his spring wire, making it increase in thickness to the outer end, in such proportions as to cause the balance—when thrown to a greater extent of arc—of vibration, that it should return the quicker; but, to his sorrow and disappointment, his chronomoters were constantly losing on their rates. To overcome this difficulty, he left them fast in the short arcs of vibration; thus, then, showing Arnold was the better educated and a more scientific man than Earnshaw. But, on the other hand, Earnshaw's workmanlike and mechanical genius was greatly superior to Arnold's.

Having concluded the introduction to this Essay—the subject is one in which I take the deepest interest, and I am well aware how difficult is the task I have undertaken,—I now design to seek that which is good and true, and that alone.

CHAPTER I.

On the Practical Details for Making Compensation Balances, with a Discussion of the Metals to be preferentially employed, and of their proper proportions.

EARNSHAW'S Chronometer Balance, or Compensation Balance, in use to the present day, and known as the balance of ordinary construction, is made in the following manner:—

A piece of the best cast steel is selected suitable for the purpose, a hole is drilled through it and brooched out to its proper size, perfectly straight, a circle is struck on the piece of steel, which is filed or rounded to this circle; the size and thickness being determined upon according to the size the balance that is to be made. It is then set up in a lathe, and turned perfectly flat on both sides, and true on the edge. This being done, it is removed from the lathe, put on to an arbor placed in the turn benches, and caught or tipped perfectly true by hand to its exact size, as the size cannot be altered when it is fluxed over with brass; the hole is then filled up with black-lead, to preserve it, and to prevent the brass running into it (in which case the centre would be lost); it is then put into a crucible with as much of the best brass as will cover it, the crucible being placed within a small furnace or stove

[m]ade for the purpose, and the melting pro[ce]ss commences. The operator watches the [p]rogress of the melting of the brass with [g]reat care; experience is required in this [p]rocess, as well as all through the manipulation of the balance. When the brass has sufficiently run or fluxed over the steel, it is removed from the furnace, and allowed to cool gradually. This operation having been finished to the satisfaction of the workman, the superfluous brass is filed off, and the edge, which is now thick with brass, is well and carefully hammered until it assumes a degree of hardness. This hammering will soon prove if the melting has been well and properly done. It is now again removed to the lathe, and set up perfectly true and flat, and turned out to its required depth and thickness. It is then taken from the lathe, and the arm is now filed or crossed out to its proper shape and figure. Great care is required in filing or crossing out the balance, that the files do not slip on to the turned edge of the rim. Judgment is now required on the part of the workman in obtaining and working up the balance to its proper proportions, which experience has determined to be thus:—one-third of steel to two-thirds of brass. So that, if the rim of the balance under construction is to be three-hundredths parts of an inch in thickness, its proper proportions should be two-hundredths parts of brass to one-hundredth part of steel; whatever thickness the rim of the balance is to be made, this is an universal rule, carried out in the making of the compensation balance for the smallest watch up to the ordinary two-day chronometer. It is a known fact that both brass and steel expand in heat and contract in cold, the ratio of the brass being 3 as nearly as possible to 2 of steel, or, as 3 are to 2. The brass has a tendency with every change of temperature to move one way, the steel has also a tendency to move the same way, but not so rapidly; but the force of the brass bends the steel with it. Thus, then, the two metals act pleasantly and uniformly together. In making balances, great care must be taken that they get no bruises or bendings, for if they get a bruise on one side more than the other, so as to indent the rim—that part will be less affected by heat or cold than the other portions of the balance. A method of rubbing the brass with heavy burnishers whilst the balance is in rapid motion upon the lathe has been suggested by some, but it appears almost impracticable that the pores of the balance can be so well filled in, or that a sufficient degree of hardness can be imparted to the balance by this means, and the hammering process is so well managed that very rarely an indentation occurs upon the steel. Two screw holes are now drilled, one on each side of the arm, directly opposite each other, to which are affixed the mean-time screws. The balance maker now sees that it is all well filed and squared up quite true, and that it is free from flaws or sandmarks; and the rim of the balance may now be said to be ready for polishing. It is again set up in the lathe, and it receives a beautiful polish, which is usually done with the finest emery, and polishers of steel and ivory, the latter imparting to it a very square and clean appearance. The rim of the balance may now be supposed finished; it is taken from the lathe, carefully cleaned, and ready to receive its weights and mean-time screws. The weights of the compensation balance are made in the following manner: A piece of the best brass, well hammered, and sufficiently large in circumference, is set up in the lathe; a ring is turned in it so as to fit the rim of the balance; this piece is then divided by a wheel cutting engine into twelve or fourteen parts. Then you will have six or seven pairs of pieces of equal size and weight, which are either turned or filed into the required shape. A well-made screw is fitted with countersunk head into each of the weights, which fixes it to the rim of the balance. The mean-time screws are also now fitted. The weights of the balance when fixed at equal distances will produce a balance in the full sense of the term, equal in all its parts. As the weights on the rim of the balance require shifting for the purpose of adjustment for compensation, a good deal of attention is required in the fitting of the slot in the weight to the

rim of the balance, without bending or twisting it. The circular, clean appearance of the weights when finished, gives to the balance a very handsome appearance, and it is a piece of work when well made that does the workman great credit.

The compensation balances for watches and pocket chronometers are made precisely in the same manner, as described. The size of balance being determined upon by the size of the steel before melting or fluxing over with brass. After the rim has been made to its proper size, four holes are drilled, one at each end of the arm, and the other two exactly at equal distances from the centre of the arm, and standing as it were in two straight lines. These are turned quarter screws, which are never altered for the purpose of compensating, but are used for timeing in different positions, or in bringing the balance under the perfect control of the pendulum spring. A series of holes are drilled at equal distances from each other, being all properly divided by a small dividing plate, and fitted (generally) with six or eight screws on each side of the rim. The proper weight of the balance is made up by the number of screws applied, which should all be well and exactly made, so that each screw shall fit nicely in any of the holes tapped in the rim of the balance, so that the screws may be removed from one hole to another as may be required for the purpose of adjustment for compensation. Often great trouble and annoyance are given to the practical adjuster by having balances to work upon with screws fitting only in the holes as they are placed by the balance-maker. In all balances made for adjustment, it is a very important point for the maker's attention to see that each screw shall fit well and properly in any hole of the rim of the balance what may be determined upon for the final adjustment of the balance in compensation. In no part of the trade is there more trickery than in this highly-flaunted word—compensation balance. The adjusting of it being understood only by a few watchmakers; and I here boldly assert, not one watch out of one hundred sold to the public as compensation balance watches are adjusted at all. The enormous quantity of Swiss watches with which our home and foreign markets are glutted, have mock or imitation compensation balances very badly made, and not cut open or through the laminæ. These balances certainly, as far as time-keeping properties are concerned, are useless, and are simply imitations of a good compensation balance.

There can be no doubt that balances composed of brass and steel, made with properly proportioned laminæ, have answered so well, that a recommendation of other metals must be received with great caution. Compensation balances have been made of silver and platinum; these balances were of large size, and being very soft, they were cut open in the centre: I much question if they would retain their figure if cut open at the ends, close to the arm, from the degree of softness they possessed. From this cause the metals are not so suitable as brass and steel, which, when used in proper proportions, the balances so made maintain a degree of truth and firmness not to be surpassed by the use of other metals. And from experience we find a well-made balance will compensate for the variations of the pendulum spring, from the smallest size watch up to the largest chronometer balance, retaining its shape and figure and acting easily and comfortably in a temperature of 30°, with an error, which will form the subject of another chapter; and when we see the wonders the ordinary compensation balance has done, in reducing from minutes to seconds the errors uncompensated or unadjusted watches are liable to, one may exclaim—"How much nearer perfection can we arrive?"

CHAPTER II.

A Description of the Practical Operations of Compensating Watches and Chronometers by the Balance.

In the first place, before commencing the adjustment of chronometers or watches, it will be necessary for me to impress upon the operator the necessity of having a good

[r]egulator, with the pendulum so adjusted [th]at he knows the error or rate of his clock, [fo]r sometimes clocks seem suddenly affected, [a]nd will err occasionally, but a well-made [c]lock, with a mercurial pendulum, a chronometer maker looks upon as absolutely necessary for this purpose. Also a good oven or heat chamber, so constructed that the temperature will remain stationary at the point of the thermometer determined upon for the purpose of adjustment. Another important requisite is an ice-box, which are so made that a temperature of 40° or 50° may be also obtained stationary for two or three days together, at a small expense for ice.

We will suppose all these things in good order, and the practical operations of adjusting chronometers and watches for their errors in compensation are carried out in the following manner:—1st. Having examined in every part his chronometer or watch, and freed it from all mechanical defects, and seen that it is well sprung and going steadily to mean time, it is compared with the clock, and its errors noted in a book kept for that purpose. The chronometer or watch is placed in the oven for twelve hours, at a temperature, say of 85°; at the end of this time it is again compared with the clock, and found to have lost six seconds. It is now removed to the ice-box, and allowed to remain there twelve hours; and, on comparison at the end of this time, he finds his watch to be, say mean time. This shows the piece has gained six seconds in cold, and lost six seconds in heat in each twelve hours of trial, which error being multiplied will give the error the piece is out in compensation—twenty-four seconds per day. Before making any alteration, it is always advisable to repeat the trials, to see if they corroborate, or nearly so. If they do not, something is wrong in the piece under trial, and the operator may be altering for compensation a defect in the mechanism not to be corrected by the balance. But as I am writing on the balance—and it is my duty to confine my remarks as described by the conditions of this essay—it will be necessary for me to consider the watches or chronometers under trial for compensation as perfect as good examination can make them; that the springing and isochronism are correct, and that the escapement is properly set or adjusted to the balance itself.

The experienced timer must be sure all this work has been attended to, otherwise (as before stated) many faults will creep in, which, I fear, is too often the case, are put down to the balance, which it cannot, nor is it, its place to correct. The error of the piece under trial is found to be twenty-four seconds per day; the alteration for this amount is made in the following manner:—The weights on the rim of the balance are shifted to a position more forward on the rim. The balance will be seen by the drawing to be cut open at a short distance from the side of the arm; the compensation not being sufficient, the weights must be shifted towards the ends of the rim, so as to be more altered in place when the curvature of the rim of the balance is changed by an alteration of temperature. For an alteration of twenty-four seconds per day, the weights must be shifted forward about one-tenth part of an inch, and again tried, until the watch or chronometer performs the same at 50° and 85° of temperature, or at whatever two points of the thermometer the chronometer maker fixes upon.

Example No. 2.—I have a chronometer under trial, and find it to be gaining in heat and losing in cold eighteen seconds per day. We now see that the compensation is too great. This is corrected by shifting the weights backward, or nearer their attachment, so that they may be more influenced by the alteration of the curvature of the rim, and, for an alteration of eighteen seconds per day, the weights must be shifted back to the distance of seven-hundredths part of an inch, and so on until the piece under trial performs the same at 50° and 80°, or, as before stated, at whatever two points of the thermometer may be decided upon by the person adjusting it. If fifty examples are given it will be useless, as the

same law must be carried out, according to the variations of the watches or chronometers under trial.

Example No. 3.—Balance No. 2* is a balance with screws; the principle of both is the same, and the only difference is this—that the necessary weight is given in No. 1 by a single piece *w* on each arm of the balance, whilst in No. 2 it is distributed among the screws which are inserted into the rim of the balance. So much now depending upon the size of balances with screws, no rule can be given as to the number of screws to be shifted forward should the watches be losing in heat and gaining in cold. The number must always be determined upon by the skilled timer, who, in some cases, may have to add screws of a heavier metal, such as platinum, to obtain a proper compensation.

The Plate Licence Question.

At the usual quarterly meeting of the Leeds and District Watchmakers' and Jewellers' Association, held on Tuesday, July 21st, the following resolutions in reference to the plate licence were unanimously passed:—1st. That, in the opinion of this meeting, the Plate Licence Act is unjust and oppressive, inasmuch as it does not give sufficient protection to licensed dealers against defaulters. 2nd. That this meeting is of opinion the Plate Licensing Act should be so altered so as to necessitate the licensing of any person dealing in jewellery, whether it be gold, silver, plated, or gilt, irrespective of quality or quantity. 3rd. That the foregoing resolution, together with a petition signed as numerously as possible by licensed dealers and jewellers, be forwarded to the House of Commons, and that jewellers in other towns be respectfully requested to take similar action in the matter. Petitions are being numerously signed at Leeds, Bradford, and other towns in the West Riding of Yorkshire.—[We are requested to state that Mr. M. Tanenberg, the honorary secretary, of 5, Dodsworth Court, Briggate, Leeds, will be happy to communicate with any person willing to aid in achieving the objects of the association.]

* The author gives drawings of this and various other balances, which will be reproduced with a subsequent chapter to which they more immediately refer.

Review.

A Rudimentary Treatise on Clocks and and Bells, by Sir EDMUND E Bart. (*late E. B. Denison*), Q.C., F.R.A.S., *President of the Horological Institute. Sixth edition. Lockwood and Co.*

The reprinting of the sixth editior standard work, in smaller type, to a the author tells us, increasing the cost of the book, does not appear been *entirely* successful, for, althou book is unquestionably diminished its cost is greater by more than one However, no one will object to th now charged for the only modern tre clockmaking, which is, moreover, of worth, as the exhaustion of five sufficiently testifies. The present much nicer arrangement of the sections than the fifth edition. T torical matter is arranged with dis tion, and has been brought down to date. The chapter on bells, which h enlarged, is a most important sectio book, and contains abundant eviden inventive power of the distinguished Many additions and some excisio been made, generally with advantag must, however, take exception to clusion to which the author leads th at page 278. If the author think consequence that his watch "goes faster at one time of the day than a no one can fairly object; but the fa holding that opinion, together w having "seen watches with tapere springs in which you could not perc difference in the force by the usual apparatus of a weighted lever," is c not sufficient to justify his brand fusee (which is really a distinctive fe the best English work) as "superfluo "mischievous" in watches. We are t anxious to protest against this unw deduction on account of the weigh is likely to be attached by the publ assertion of such an unrivalled a upon all matters connected with larg as Sir Edmund Beckett, and also count of the general excellence of th which would be is an acquisition t young mechanic. The section on t of wheels is particularly clear and g the original thought and sound me ideas pervading those portions de clocks and bells well sustain the wor reputation of the designer of the minster clock.

WHEELS AND PINIONS: THEIR SHAPE AND DIAMETER.

By RICHARD LANGE,
Glasshütte, Saxony.

[Much to our regret, this Paper has been delayed in transit for several months.]

In some numbers of your esteemed journal, as well as in Reid, I found the proportions for the diameters of the pinions to that of the wheels which are to pitch into them.

I was surprised somewhat to find in these statements that the proportions differed as the wheels and pinions to be employed and destined for pocket-watches or clocks increased or diminished in size; in a scientific point of view, no theoretical or practical reason was given to explain this.

In respect to theory it is quite clear that the proportions of the primitive diameter or pitch-circle of each pinion to the primitive diameter of wheel is as the proportion of the number of pinion leaves to same number of the wheel teeth.

For instance, should the number of pinion-leaves be 10, and the wheel-teeth=80, then the proportion will be as 1 : 8; hence, if the primitive diameter of wheel be $8^{mm.}$, this of pinion must be 1^{mm}.

We mean by the primitive or pitch diameter of wheel or pinion, the true or full diameter, diminished by the rounding of the tooth-curve.

It is evident there is no difficulty in finding this; every scientific work since Huygens will explain it.

It would be easy:

1st. To find the mutual proportion if the distance from the centre of the wheel to the centre of pinion is given. Returning to the former example, where the wheel has 80 teeth and the pinion 10, but let the distance from centre of wheel to centre of pinion in this case be $9^{mm.}$; then the diameter of wheel would be $16^{mm.}$, and the diameter of pinion $=2^{mm}$.

2nd. In the same way, it would be an easy matter to calculate from a wheel with 80 teeth and $16^{mm.}$ diameter, the primitive diameter for a pinion with 10 leaves, because, as 10 (the number of pinion-leaves) is to 80 (the number of wheel-teeth) as 1 : 8, so we have to make the primitive diameter of pinion 8 times smaller than the diameter of wheel in question.

Only one difficulty arises — that is, to measure the primitive diameter of the wheel, in order to find the primitive diameter for a corresponding pinion.

It would be possible to do this by a finished wheel, where the curves of the teeth are made. This measurement can be done with tolerable accuracy, because it is pretty easy to be seen where the rounding of the teeth begins, it is only to measure as much less, as this rounding amounts to, and if there occurs a small fault, it would hardly be of any importance to the pinion, because this fault is divided in the same ratio as the pinion has less teeth than the wheel, or what is synonymous, in the same proportion as the pinion is smaller in diameter than the wheel. Did we measure, for instance, the wheel 0·1 too small, so the fault would be in proportion by a ten-times smaller pinion, only 0·01.

Having found in this way the primitive diameter of wheel, we have only to make the primitive diameter of pinion as much smaller as the number of leaves in pinion is less than the teeth of wheel. (After having found thus the primitive diameter of the pinion, then the full diameter is to be determined.) It is somewhat complicated to find the full diameter of pinion, when the primitive is given. If the primitive diameter of the pinion is fixed, which is very easily found by the above illustrated manner of calculation, then there is to add the amount of the teeth curve. If this rounding were uniform for all pinions, for instance 0·1, then the calculation would again be very easy, we only would have to add 0·1 to the acting or primitive diameter, to make the full diameter. But this is not the case, the quantity to add, the addenda as it is called, is in a very different proportion in a pinion of 6 leaves, than in a pinion of 20 leaves, because this addition is not in proportion to the diameter, but to the thickness of the leaves of the respective pinions.

In the following calculations and tables the respective proportion of the full diameter to the primitive, and *vice versâ*, is to be found.

Calculation, arrangement, and use of the pinion-tables.—Our pinion-tables are calculated after drawings, which originated in a rather graphical way, giving the wheel-teeth an epicycloidical, and the respective leaves of pinion a correct hypocloidical form.

1. To draw them correctly, my father employed for the diameter of the generating

circle, a disc which was half the pitch diameter of the pinion; this disc was 27 cm in diameter, and the point of a small lead-pencil was fastened precisely on its circumference.

2. He took a brass arc, representing a section of a wheel, about 324 cm in diameter, on whose ends there were two small pins, to fasten it on the paper.

3. For the pitch-circle (or primitive circle) of the pinion my father employed a metallic ring, whose interior was 54 cm, the same diameter as the pitch-circle.

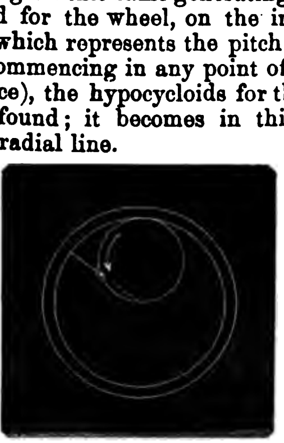
4. The disc as well as the outside of the brass-arc and the inside of the ring were made rough (like infinitely fine teeth), to prevent sliding when the disc was rolled on the arc.

By the aid of these instruments the epicycloid and hypocycloid were produced.

Epicycloid on the wheel.—The epicycloidal curve of the teeth on the wheel is produced by rolling the disc of 27 cm diam. (which represents the generating circle) on the outside of the brass-arc, which represents the pitch circle of wheel.

Hypocycloid on the pinion. — The pitch —or primitive—diameter of pinion, represented by a brass-ring twice as large as the generating circle of 27 cm will be$=27 \times 2$ $=54$ cm.

In ruling off this same generating circle of 27 cm used for the wheel, on the interior of the ring which represents the pitch-circle of pinion (commencing in any point of the circumference), the hypocycloids for the pinion leaves is found; it becomes in this case, a straight, radial line.



The pinion and wheel-teeth, produced in such a simple mechanical way, answers exactly to the strictest mathematical construction and calculation, as every mathematician will acknowledge.

By the aid of machines, invented by my father, the teeth of the wheels, as well as the leaves of the pinions employed in our watches, have been made upon this correct theoretical form and proportions.

Letters to the Editor.

All Letters to be addressed to the Editor, at the Institute, 35, Northampton Square, E.C.

To the Editor of THE HOROLOGICAL JOURNAL.

SIR,—Can you find room in your journal for a few remarks upon Mr. Savage's gold pin escapement, in connection with Mr. Schoof's paper read at the Institute on the 17th June?

By the members of the watch trade the fact is acknowledged that to the labours of Mr. G. Savage they are indebted for the improvement of the escapement. He it was who discovered its inherent worth, and, by the discernment of its best adapted proportion, and by skilful manipulation, so improved an almost useless piece of mechanism as to produce an escapement, the value of which can scarcely be overrated. Is it reasonable to suppose that such a genius would be likely, after continual experience, to introduce to the trade an escapement embodying new principles—one inferior to his earlier productions—and allege it to be superior? The probability of his doing so cannot be admitted, since in his day the prejudice against the lever escapement ran so high, that he did not scruple, at times, to offer to forego all pecuniary claim, if, upon trial, his escapement failed to give satisfaction, such was his confidence in his own productions. It cannot, however, be doubted that some individuals of Mr. Schoof's audience must have received the impression, through his remarks, that Mr. Savage had failed to surpass his single-pin escapement, and that his gold-pin escapement proved but a sorry affair. For myself, I am almost tempted to believe that Mr. Schoof never had under his examination a correct gold-pin escapement: if he has he scarcely could have failed of observing the matured ingenuity that must have been exercised in its design. But he does seem to have failed to observe this, and the fact can only be attributed to his not having bestowed that scrutiny upon the escapement its worth demands, and which might have

pected from one of his acute percep- mechanics.

ut a thought upon what Mr. Savage to do when he designed his gold -pin escapement, I will endeavour in what he has done, in the hope of g the vague notions that are evi- xtant concerning it. Its general ng well known, I shall not be precise tail; yet there are particulars that especial notice. The chord being into three parts gives the proportion the lever and roller, the larger for the lever; this, with a pallet of s an escaping arc of 30°. The gold e lever is very fine, the square notch he edge of the roller narrow. The g pins are placed near the edge of r, and less than 30° apart, so that, e escaping arc is completed, the f the lever fork will scarcely have the line of centres; it is, however, up to that line by the draw of the The opening of the fork is continued ch side of the impulse pin, to make the passage of the unlocking pins, gagement in the fork being very The engagement of the impulse pin roller is two-thirds its diameter, fork is opened sufficiently wide to e pin to enter the roller-notch freely. an necessary freedom Mr. Savage l a great defect; he therefore made nt to leave this nice adjustment to pleted by the polishing of the fork. nes of the pallets are as long as . The engagement between the nd pallets is very light; the draw e pallets light also, so light that a with the teeth sloped rather more ose in present use is preferable, to insure a safe locking; with this of action perfection of the wheel an absolute necessity. The action scapement is the perfection of light- l velocity. The unlocking is effected e line of centres by a smart, quick d is neither retarded by a sluggish, draw upon the fork, nor checked by ce of dead friction upon the pallets. ss of action is further promoted by ulse-pin remaining in action through test part of the escaping arc, leaving le supplementary arc to be effected ns of the unlocking pin. At the of unlocking, the impulse-pin seems nto the notch, the drop being scarcely ble. Velocity is further augmented adoption of a proportionably large nd short lever, and, by the latter power is economised thus:—When the scape-wheel acts immediately upon the roller, as in the detached escapement, its force is more effectual than when trans- mitted to the roller through a lever, as leverage then diminishes the wheel force; it follows that, as the lever varies in length, so will the effective force of the wheel vary, being greatest when the lever is shortest.

I once had in my possession an escape- ment, made either by Mr. G. Savage or his brother, and the above are my observations upon it.

Mr. Schoof will perceive how entirely he has misunderstood its principles, and that "rebutting," and the other faults he has pronounced to be detrimental to its good performance, have no place in it, and are but the creation of his own imagination. Mr. Schoof, it will be observed, remained silent upon two important features: the angle of the pallets, and the amount of their engagement with the wheel; so I think it probable, from his explanation of the fork action, that the escapement he had in view must have been constructed after the mode of the single-pin escapement, the fork action excepted, for the deeper engagement of the wheel with the pallet and the general pro- portions, though in themselves good, are unsuitable for the three-pin escapement, as they would certainly produce the defects with which he has invested it.

Mr. Schoof, if he is open to conviction, will also perceive that the attempted im- provements to which he has alluded were but the tampering with sound principles, and not undertaken because Mr. Savage failed to accomplish "that at which he aimed," but because the making his escape- ment was undertaken by workmen un- acquainted with its merits; hence results became unsatisfactory, and are now ascribed to Mr. Savage's supposed incompetency rather than to the workman's meddling.

That Mr. Schoof's escapement, Fig. 1, is superior to his imaginary three-pin escape- ment is true, and that it is inferior to Mr. Savage's escapement is true also.

E. STORER.

July 25th, 1874.

SIR,—We noticed some remarks by Mr. Schoof on the thickening of oil in watches, that had been in cases made of cedar, and can quite endorse what Mr. S. says, having experienced the same thing ourselves. Having no mahogany here, all our show cases have to be made of cedar. We had a new case, and after having it in the shop for some little time, we put in it some silver

cups, and were very much annoyed at seeing them turn almost black in a few days, and the tarnish was so thick and quite sticky, showing very clearly that the wood must contain a large percentage of a resinous gum. We have since had some cases made, and allowed them to get thoroughly dry before using, and then it does not seem to have much effect, leaving the lids, &c., open.

We have also had the same thing occur in an eight-day English dial, which had been fitted into an ornamental case, made in Sydney of cedar; the clock stopped in less than a month, the oil being as thick as tar.

We are, yours, &c.,
F. ALLERDING & SON.
Sydney, New South Wales.

Sir,—I have perused the letter of Mr. Rebbell, and am not surprised that the Astronomer Royal does not enter into the question, for a very simple reason. Professor Airy is a very sound mechanic.

The sympathy between vibrating pendulums has been largely over estimated.

The mutual "gravity force" of such small masses as the bobs of pendulums is far too small to cause such effects as has sometimes been attributed to it.

I never yet met with a case of the sort described by Mr. Rebbell, that upon investigation did not turn out to be one surrounded by causes purely mechanical, sufficient to produce the effects without any necessity for travelling beyond the visible into the region of the invisible for an explanation.

These causes are two in number, firstly—insufficient stability of the support of the clock; and secondly—the surging of the atmosphere in which the pendulums swung.

The first, although the vibration of the point of suspension caused by such instability may be small, the effect is cumulative on any other body swinging in its neighbourhood, and that in proportion to the degree of synchronism between the two. This has never failed to disappear upon making the suspensions immovable. The effect, however, is at its minimum when the planes of vibration make a slight angle.

The other cause applies mainly to bodies swinging in confined spaces, but in this, as in the former case, the effect becomes more and more apparent as the times of vibration approach coincidence, or some well defined difference, such as the half or the quarter of either.

In the case named by Mr. Ribble, I should suppose neither of the points of suspension as steady as they should be.

No amount of *apparent* stability in a *pedestal* that I have ever seen will prevent vibration at the point of support of an ordinary seconds mercurial pendulum, and I have no doubt that if sound mechanical means are taken to insure perfect fixidity of the centre of suspension of the astronomical clock, the effect noticed will disappear.

Yours, &c.,
E. D. JOHNSON, V.P.
9, Wilmington Square.

To Correspondents.

In answer to "P. E.," the mode of procedure for polishing wheels depends upon whether they are solid, like the main and centre wheels, or pierced as the third, fourth, and pallet wheels. Taking a centre wheel first, lay it flat upon a piece of cork screwed in the vice, and rub it with a piece of bluestone, snakestone, or water Ayrstone (which must have been rubbed square and flat upon an even stone or board with sand), keeping it moistened with water, guarding the pinion with the finger and thumb; keep the stone flat on the wheel, and do not rub too long in one place. This done, screw a ferule on the back arbor, put it in a small pair of turns with a hair bow on the ferule, and with a broken bit of bluestone and oil rub the wheel till all the scratches are out, pulling the hair bow up and down with the left hand. For the next step, use for a polisher a bit of cedar wood, moistened with the oil that has become thickened by the stoning process, until the wheel looks somewhat bright and free from marks; then clean the wheel thoroughly, and polish in the same way with burdock dipped in fine red-stuff mixed with olive oil, taking care to cut all the wood part of the burdock away till only the pith remains. Some prefer to use coarse red-stuff before the fine. The pierced wheels, after undergoing the bluestone and water and bluestone and oil processes upon a cork, are polished with wheel metal and coarse red-stuff until all the teeth and arms of the wheel are up square or flat; then the wheel and cork should be properly cleaned, the metal filed up, and the wheel finished with fine red-stuff. The wheels should now be washed out in soap and water, dried in lime, and burnished, taking care to rub the burnisher upon a board that has rottenstone upon it. To ensure success, the polisher must be kept perfectly clean, and care taken that all scratches are removed before attempting the latter stages.—W. Makepiece Howe.

Transit.—*The principal instruments used by Halley, Bradley, Bliss, and Maskelyne are still preserved in the Royal Observatory, Greenwich, and were shown to the members of the Institute on the occasion of their visit last year.*

British Horological Institute.

VISIT TO WOOLWICH ARSENAL.

BETWEEN sixty and seventy of the members of the British Horological Institute, by favour of the Ordnance Department of the War Office, paid a visit to the Royal Arsenal, Woolwich on Tuesday the 15th September. Not all members, strictly speaking, for one or two ladies graced the party, which assembled at the Gates of the Arsenal at twelve o'clock. After waiting until a quarter past for stragglers, we were taken in tow by Mr. France, who proved to be a thoroughly competent and painstaking guide, and after a short delay caused by the Secretary having to formally announce the presence of our party to Major Maitland, the Director of the Gun Factory, ushered into that portion of the works devoted to the forging of the gun coils.

As soon as the members were ranged at what seemed a respectful distance from the operators, the furnace door was lifted and a bar of iron at nearly white heat, about 25 ft. long and in section $3\frac{1}{2}$ in. square, was withdrawn by means of a formidable pair of tongs supported from a crane. Those who, with a smile of satisfaction, had formed themselves into the front ring of spectators, now exhibited some anxiety to enlarge the semicircle; not perhaps on account of the excessive heat so much as with a desire that their uninterrupted view might be shared by as many as possible; but to no purpose, those behind with commendable self-denial expressed themselves quite content. Meanwhile the end of the square bar, by means of a hole already punched through it, had been fastened to the collet of a mandril, and the mandril being caused to revolve, the red-hot iron bar was coiled up after the manner of a helical spring, but that the coils were kept as closely together as possible. This, the first step in the manufacture of a forty-pounder, was accomplished in what seemed but a few seconds, and we were conducted to another furnace to see the operation of welding the coils together, performed with marvellous ease and skill. The tongs this time drew from the furnace, at a welding heat, such a large coil that the $3\frac{1}{2}$ in. bar for the forty-pounder, which we had just seen twisted, seemed positively insignificant. It was swung on end to the anvil-block of a 6-ton steam hammer, leaving a trail of half melted drops of iron. The tapered end of a mandril having been entered into the central hole and driven down with a couple of little taps, it was turned over on its side and subjected to a few blows that made the ground tremble. At each blow the lines marking the coils became fainter and fainter, until at last the mass became a cylinder with nothing to mark the manner in which it had been coiled up from a square bar.

A discussion here arising as to whether the hammer we had just seen in operation were the largest in the Arsenal, our guide—looking aghast—conducted us with trembling haste to the famous Woolwich hammer, and with justifiable pride, but rather bewildering glibness, detailed the various dimensions and weights, from which we managed to catch that the hammer weighs 39 tons, that it is lifted fifteen feet three inches, that the weight of the hammer in falling is supplemented by steam pressure, that in the foundation were used 750 tons of cast-iron plates, one weighing 103 tons—we presume this to be the anvil-block. The furnace, close by, built to prepare the "heats" for this monster, has a capacity equal to 2,000 cubic feet; and is 13ft. high, a "heat" requires 24 hours to attain the desired state, consuming 4 tons of coal. For a moment we were lost in admiration of this steam hammer, which is really a splendid tool, and (although the Russians have one whose hammer weighs more) it is, taken altogether, the heaviest and most ponderous tool of its kind in the world. Looking round we found the members had all hastened back to the shop we had quitted for fear they should not see the machinery at work, it being being nearly one o'clock—the dinner-hour of the workmen. After taking a glance at an immense forging lying in the yard—the trunnion-piece for one of the 60-ton guns, the Woolwich Infants—we hurried in the direction our party had taken: we found them watching the process of rolling bar-iron. First a shapeless lump of iron at a white heat was drawn through the largest grooves in the rolls, and (the mill not being reversible) passed back over the top

roll, and through a smaller pair of grooves, back again, and through still smaller grooves, until the mass of iron, each time lengthening and becoming more shapely, was at last drawn away by two men a finished bar, 18 feet long, with sharp corners, and an uniform section of 4 in. by $\frac{3}{4}$ in. After an inspection of Crampton's revolving puddling furnace with its arrangement for the economical feeding of powdered coal, destined to work a revolution in the manufacture of iron, we betook ourselves to the turning department. Almost the first object that attracted attention was the inner steel tube for the 80-ton gun, being made from probably the largest ingot of steel ever cast in England. It was manufactured by Messrs. Firth, of Sheffield, who cast the ingots for all the steel tubes used in the Woolwich guns, producing a quality of steel not excelled by Krupp, the eminent Prussian steel manufacturer and artillerist. The tube, or rather lump of steel, for it is solid when received from Sheffield, weighed 16 tons, and cost £1,500. It is said that the Russians, for some of their guns made entirely of steel, cast ingots weighing 40 tons, perfectly homogeneous. In this department we saw our old friends—the coils—in every size and stage of machining, being turned on the outside, having their insides bored and their ends reduced to the exact size, or at least, as our guide told us, to within the $\frac{1}{1000}$th part of an inch, to allow of the next tube obtaining a grasp of it by being shrunk on. The tool for cutting the twisted grooves which form the rifling of the guns, is a beautifully simple and elegant idea. The gun is held stationary, the cutters are fixed in a head at the end of a bar, which projects so as to allow the cutters to reach the end of the bore before the muzzle of the gun can touch the support of the bar; looking at first sight not unlike the swab with which the guns are cleaned. The slight rotatory motion required is generated by a pinion, which is fixed on the cutter-bar, gearing with a rack having a gradual and uniform motion at right angles to the axis of the bar.

Leaving the turning department we were taken to the model room, where are ranged finished specimens of the various service guns, as well as the now obsolete Armstrong breech-loader. Also a section showing the construction of the Woolwich gun. Upon a tube of steel, which, as we had previously seen, is bored for its whole length excepting sufficient to form a solid end, and turned slightly taper the muzzle end being the larger, is shrunk a wrought-iron coil, made in two or more sections, to such a length that several inches project beyond the solid end of the tube, when both coil and tub are fair at the muzzle. An internal threa being cut upon the projecting portion of th coil, a plug is screwed in up to the end (the tube, supporting it when the recoil occu after firing; and by being slightly tapere from the muzzle, the tube in recoiling has tendency to tighten in the coil. Upon co number one, or the A coil, as the official term it, is shrunk another wrought-iro coil not so long as the preceding, and if th gun be a small one, this second coil ha attached to it the forging carrying th trunnions, and the construction is complete For the larger guns three wrought-iron coil are used altogether, in addition to the stee tube. The two great points of distinctio between the construction of the Woolwic gun and the Krupp gun adopted by Prussi and with modifications by Russia and othe countries are—the former is muzzle-loading built up of wrought-iron with a steel lining and the latter is composed wholly of stee and loaded at the breach. While no gu upon the present Woolwich principle ha ever burst, although the lighter for a give weight of projectile, the steel guns are co tinually bursting, often with disastrou results; and looking at the question of cos the advantage is again immensely in favo of the Woolwich system, and being le costly, the Woolwich gun takes less time t make—not an unimportant consideration i time of war. The largest steel gun yet mad is the 1,000-pounder, presented by Krup during the late war to the Emperor of Ge many, it weighed 50 tons, and cost £16,00 The new Woolwich 80-ton gun will be 1,600-pounder, and is estimated to co about £8,000.

From the model room we went to th portion of the yard called the cemetery dedicated to specimens of the guns propos and in use during the last 300 years—so whole, many in fragments, having burst o trial. For a long period the advance woul seem to have been small, a slightly differe shape, here a little more metal round th muzzle, there stronger at the breach, a fe of bronze, but most of cast-iron, includin some breach-loaders of fearful strength, th invention of an American, and sold to th British Government by weight. At la came the sudden and gigantic stride of S William Armstrong's breach-loader, event ally perfected by the Fraser system of co and the abandonment of the breach-loadin mechanism, becoming the present Woolwic gun—the finest in the world. A promine object in the cemetery is the notorio 2,000 lbs. mortar, built in deference to t

ist notions of Lord Palmerston, and burst after a very short trial. Here t the precincts of the gun factory for boratory, as the portion of the Arsenal d to the production of projectiles is , and lost the services of our obliging , Mr. France.

er obtaining a fresh guide we entered uilding containing finished specimens erent projectiles. The shrapnell shell, led with a fusee, was shown in section, ne Pallisser pointed shell, in which the is exploded by the heat generated shell's concussion with the armour-against which it is fired. While int of this shell is cast in a chill, the portion of the mould is of sand; and section the hard and softer portions steel are easily discernible by the nt textures.

invention of Colonel Boxer's for ob-g the movements of an enemy by was the subject of much attention. It ts of a parachute having a cup of fire ded from it by cords. The parachute is doubled up, and the whole, cased in the f a sphere, is to be fired from a gun rtar to as nearly over the supposed n of the enemy as possible; when the ute will expand and the fire be ig-

Leaving this building, we went to le-bullet and fusce factory. The first in the manufacture of rifle-bullets—ng the solid lead under hydraulic re—is fully described in Volume XII. HOROLOGICAL JOURNAL, page 49. The of lead, being passed to one machine, t off in proper lengths and hollowed 1 end, leaving a diaphragm near the . Another machine shapes or draws int of the bullet over, leaving the inside for a proper balance. A third the concentric grooves that take to the of the gun. Although the point has closed over, the hollow at the back of illet remains, and is now filled by a r wedge of pressed burnt clay, which moment of firing is driven further e hollow, expanding the bullet so that the grooves forming the rifling. From ftness of the metal operated upon, the -making machines were worked very y. The lathes for turning the brass for shells were fitted with revolving holding six or seven tools very similar rest shewn by Mr. Fraser, of Kenil-at the exhibition of work at the te in December last; and they appeared rk remarkably well. In fact, we l one man chuck a brass casting, turn, and face it, face the back of the hole, turn a hollow at the front of the hole, cut an internal thread, and take it out of the chuck all in two minutes.

Many brass castings of secondary importance, instead of being turned and shaped, were pressed to shape and size in dies with great rapidity.

In another room copper percussion caps were being made in four processes; first, a circular piece was punched from a sheet of copper, and the edges turned up slightly; by another machine it was drawn into a long cylinder with one end solid, next the open end of the cylinder was faced off to a length, a boy placing them in holes drilled round the edge of a revolving chuck at the rate of 20,000 a-day, as the written record of his previous day's work, attached to his machine, testified. After being faced off to length, the edge was turned up to form the rim, and the cap was finished ready for the drop of fulminating powder. After a short visit to the foundry—where the shells were being cast, and an adjoining room where they were being turned by revolving against grindstones, which seemed to us to have an unnecessarily slow speed—we proceeded to the carriage factory. The chief feature that attracted attention was the adoption of Perrin's band-saws for cutting wrought-iron. This was, we were told, first suggested by an artificer in the carriage factory in 1866; and upon trial was found to answer very well, working at a speed of 250 feet per minute.

After the carriage factory came the wheel factory, and here also machinery is used to the utmost extent; as far as we could see, no handwork whatever was used in fashioning the wood; everything is worked to gauge, and without any preparatory trying or fitting, the box, felloes, and spokes were taken and all forced together by hydraulic pressure; nothing appeared loose, nor was there the least sign of cracking.

A very short inspection of the completed carriage department brought to a close, at half-past four o'clock, a most enjoyable and instructive excursion.

WATCHMAKING.—The *Journal de Genève* says the total number of inhabitants of Switzerland engaged in the watch trade is 37,969, of whom 25,242 are males, and 12,727 females. In Berne the annual production of watches is 500,000, worth 20 millions of francs; in Geneva, 150,000, also worth 20 millions of francs; in Vaude, 150,000, worth eight millions of francs (here also 30,000 musical boxes, worth two millions, are manufactured).

PRIZE ESSAY ON THE COMPENSATION BALANCE AND ITS ADJUSTMENTS IN CHRONOMETERS AND WATCHES.

(*The Baroness Burdett Coutts' Prize.*)

BY W. B. CRISP.

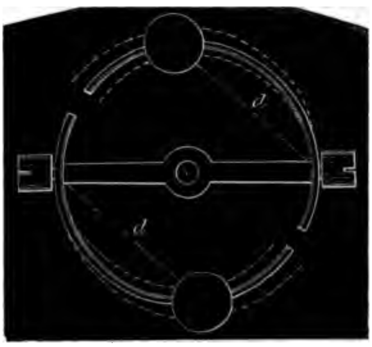
(*Continued from page* 12.)

CHAPTER III.

On the various Modes of Adjusting for Extremes of Temperature by means of Auxiliary Compensation or otherwise.

IN my last chapter, describing the method of adjusting a chronometer at 45° and 85°: supposing the same to be going to mean time at each of these points of the thermometer, on trying the instrument in an intermediate temperature of 65° it will be found to gain 1·5 seconds.

Ordinary Compensation Balance.



Ordinary Compensation Balance, with Screws.

This error is perfectly well known to chronometer makers as the "Middle Error Temperature," and the greater this error is as the chronometers are tried at higher or lower degrees of temperature. Thus, if a chronometer is tried at 30° and 90°, its error at 60° will be 2·7 seconds, or at 30° and 100°, its error at 65° will be 3·8 or 4 secon This calculation is taken from results the performance of upwards of one hund chronometers.

In an essay of this description it will impossible for me to describe the numbe auxiliary compensation pieces invented made by Mr. Eiffe and Mr. Molyneux; descriptions of their improvements are p lished and well known to chronome makers. But, for the purpose of explain the mode of correcting this error, it will necessary for me to select those applicati tried by myself, and best adapted to purpose. I now select one of Mr. Molyneu which was patented by him, and, to use Molyneux's own words, "Having, in usual manner, compensated the balance, that its vibrations shall be equal at temperatures of 30° and 55° Fahrenheit will be found that, if the temperature raised to a greater heat, such balance v vibrate so that the chronometer will lose time or decrease its rate; but by this inv tion I am enabled to compensate for the l in the following manner:—In Fig. 1

Compensation Balance, with Molyneux's Auxili (Fig. 1).

balance, with its supplementary pieces, shown in the position it assumes at temperature of 55°, its rim being then c sidered circular, and the middle projecti portions of the supplementary pieces bari in contact with the rim. Now if the te perature be raised, the balance-rim, w the supplementary compensating pieces, w

the position shown in Fig. 2, in
ı the increase of heat, the balance
ux's Auxiliary in action (Fig. 2).

to be circular. Its free ends, to
adjusting screws are attached,
roached nearer the centre of the
1 with them carried the free ends
lementary compensating pieces,
ir middle projecting portions no
k on, or are in contact with, the
f the balance rim, and thus, by
justment of the length, position,
of the supplementary compensa-
I am enabled to compensate for
es above that at which the
ı been adjusted, while the adjust-
emperatures of 30° and 50°, to
alance had been before adjusted,
impaired."
nd modification consists of a com-
or lower temperatures, the chro-
ving been adjusted in the usual
55° and 85°.

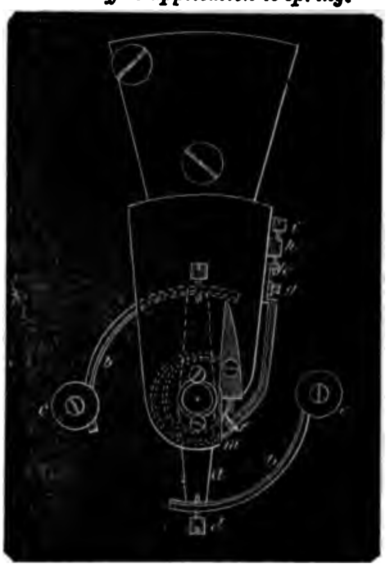
lance, with Compound Centre Bar.

modification is described by an
ompensation, screwed on to the
alance, and acting independently
ion of the balance-rim. It is
r an auxiliary adjustment acting
ı balance being adjusted in the
ner for high and intermediate
es.

Chronometers with this first modification were tested at the Royal Observatory, Greenwich, in the year 1840, and stood a very long range of temperature. In the year 1840 a chronometer, No. 1839, was on trial for thirty weeks, at a temperature ranging from 18° to 110°, its error during that time being 11·4 seconds difference between the greatest and the least; and 4·3 seconds the greatest difference between one week and the next—a wonderful performance; and it becomes very questionable, in so long a range of temperature of 92°, if the performance can be surpassed. In trials of this description, every 5° of temperature is a matter of great consideration, and, when the wonderfully close performances are published, temperature, the cause of all error, must be looked upon in the fairness of comparison between the performance of one chronometer and another, as chronometers, tested with a range only of 60° of temperature, will give very different results in so long a range as 92°.

The patent having expired, many chronometer makers have used this auxiliary with great success, and their chronometers have performed well at the Greenwich trials. The delicacy of its application, and ability required in the adjustment of it, are quite sufficient to render the auxiliary useless in unskilled hands.

Eiffe's application to spring.



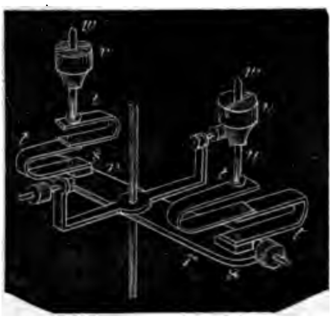
Mr. Eiffe speaks very highly of an application affixed to the side of the cock, as it is usually called, or the strong bar of the chronometer. It consists of a piece of compensation laminæ, so fitted and adjusted

that the point of a screw is made to act upon the pendulum spring. This also is a very beautiful application, and very taking in theory, but it is questionable if the general good performance of the chronometers to which it may be applied will be benefited thereby. The pendulum spring must be perfectly free from any banking or restraint upon it, to insure its requisite fine performance.

At the time Molyneux patented his application of auxiliary compensating-pieces to the balance in 1840, many chronometer makers (although very much taken with the idea of auxiliary compensation) were of an opinion that a balance of a different form must be constructed, for the purpose of overcoming the difficulty of losing in extremes of temperature, whilst others were trying auxiliary compensation and check-pieces, of almost every conceivable shape, to effect the same purpose.

The late Mr. E. J. Dent patented a balance of the following description:—A compensation diameter-bar fixed on the balance-axis, composed of brass and steel, the steel being uppermost. This bar, carrying a weight upon an upright rigid support, was the only compensating power hitherto employed. Two blocks were attached to the ends of the bars to receive the secondary compensation-pieces,

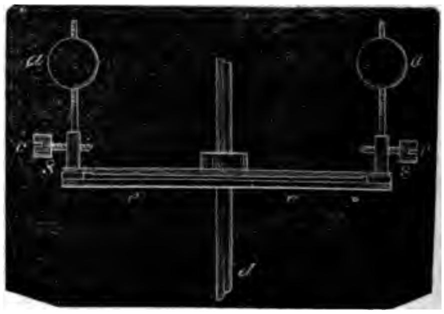
E. J. Dent's Balance.



which were so arranged that the weights should be carried upwards in heat, or tilted, as it were, into the centre, so that, by this means, the weights should always move in a line, nearly parallel to the axis of the balance. On the elevation of temperature the distance between each staple is increased in height, and, by this means, the compensation weights are lifted from the balance-bar. Under these circumstances, the primary compensation is enabled to carry the weight over a greater space, and with accelerated velocity towards the centre of motion, the reverse effect taking place on a decrease of temperature.

This balance was evidently a great improvement upon a compensation balance invented and made by Hardy, who received a reward of thirty guineas in January, 1804, from the Society of Arts for his invention. Hardy, in the description of his balance,

Hardy's Balance.



calls it "a permanent compensation balance for a timekeeper," and describes it as a great improvement upon the two balances then in use. Hardy rejected these altogether, and contrived a mode of applying the direct expansion of metals, which he found by experience to be constant and permanent. Hardy's balance consisted of a flat steel bar, which formed its diameter; beneath this steel bar were two metallic bars, one of brass, and the other of steel, secured to the first steel bar by a stud, this bar being weakened so that it should carry in towards the centre of motion two brass globes fixed upon upright standards. The first steel bar was weakened at each end, so that the compound bars had the effect of carrying the upright standards to and from the centre in heat, and the contrary effect in cold; so that the idea at that time was to have a balance so constructed that the weights should approach the centre with greater rapidity in heat, and recede slower in cold, the weights acting in a straight line to the centre. Mr. Dent remarks that "This variation of velocity to and from the centre of motion could not possibly be brought about if the weights were placed on the before-mentioned rigid immovable supports at the extremities of the balance-bar, as is usually done in ordinary balances of this description."

There can be no doubt that Mr. E. J. Dent's balance was a great improvement upon the balance of Hardy, as any balance depending or acting upon leverage or springs for the entire compensation is not suitable for a chronometer. Doubtless, from this cause Hardy's balance never came into general use. About the same time Mr. Loseby made and patented another improvement in the compensation balance, by the

application of curved glass tubes containing mercury, in addition to the ordinary compensation, the tubes being arranged in such a position as to cause the mercury, on expanding by an increase of temperature, to approach the centre of the balance at an accumulating force, corresponding to the law of alteration in the elastic force of the spring. Many very excellent chronometers with balances of this description were tried at Greenwich during the years 1845-6.*

In the year 1847 a chronometer, by E. J. Massey, headed the list at Greenwich, showing a variation of 7·7 seconds difference between the greatest and the least, and 3·5 seconds, the greatest difference between one week and the next, the thermometer ranging from 32° to 86°. whilst many of the chronometers were exposed to extremities of heat and cold from 27° to 108°. In 1848 Loseby again heads the list, with variations of 8·7 and 4·6 seconds, E. J. Massey second, and Loseby third; the thermometer ranging from 28° to 87°. In 1849 Eiffe heads the list, Poole second, Loseby third. In 1850 Loseby once more stands first, Eiffe second, Dent third. In 1851 Loseby again comes first on the list, with a variation of 16·5 and 4·3 seconds; the thermometer in this year being 34° minimum, and 102° maximum. In 1852 Loseby again heads the Greenwich list, Massey second, Dent third. In 1853 Loseby's chronometer stands fourth, and, after this year, the name of Loseby appears no more on the Greenwich trials. His application of glass tubes containing mercury is correct in principle, but the application by anyone but himself has not been attempted since the time of Le Roy, glass and mercury being about two of the worst substances where solidity is so much required, as in the compensation balance of a chronometer. In the year 1854 a chronometer by Poole stood at the top of the Greenwich list, showing the difference between the greatest and the least to have been 8·6 seconds, the difference between one week and the next 4.5 seconds; the range of temperature being from 35° to 104°. This chronometer was not beaten until 1870, and was fitted with an auxiliary compensation, now known in the trade as Poole's auxiliary. The drawings of it were exhibited at the International Exhibition of 1862. Two brass abutments are screwed

Balance, with Poole's Auxiliary.

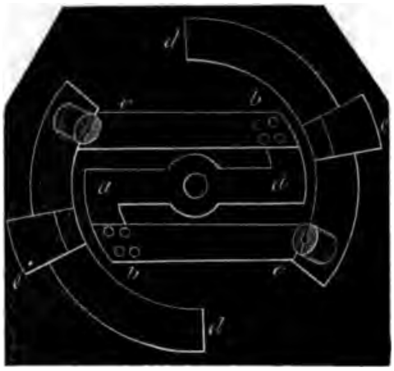
on the ends of the balance, the screw carrying the meantime screw passing through its centre. Through these abutments or check-pieces are two screws acting upon the main compensation, to compel it to act in a more limited degree in cold. The success of this balance has been very great, a large number of chronometers having been sold to the Admiralty with balances of this description not only bearing the name of Mr. Poole, but of firms that sold his chronometers, who were anxious to possess a reputation attributable to the skill of this artizan. In 1855 an eight-day chronometer by Lawson heads the list; in 1856 Muirhead, with Poole's auxiliary compensation balance, and, in 1857, a chronometer by Hornby, with a new description of balance, invented by Mr. Hartnup, of the Liverpool Observatory. From the large number of chronometers sent to the Liverpool Observatory to rate, Mr. Hartnup, by a series of experiments, soon found the defective state of the ordinary compensation balance for a long range of temperature, and further experiments have induced him to conclude that, for a range of temperature of 30°, this error may be confined to very narrow limits in a well adjusted balance.

The balance I am now about to describe was made by Mr. Wm. Shepherd, a skilful chronometer maker of Liverpool, who, in combination with Mr. Hartnup, agreed that the result of their experiments should be made known for the benefit of the public. The results of the discussions with Mr. Shepherd, who made several trials, were concluded by his making a balance of a circular form, so that the laminæ of brass and steel might be turned down to the requisite proportions with facility, and that the compensating and poising might be as easily

* The reader must bear in mind that the Greenwich trials are annual competitive trials, and in all cases commencing in the first week of the new year, extending over a period of 28 to 30 weeks; and that the difference between the greatest and the least is the whole error of the chronometer during such time of trial. The greatest difference between one week and the next explains itself, and its error is inclusive.

affected as in the ordinary compensation balance. Secondly,—the balance must be so contrived that the compensating rim and weights should move towards the centre with an increasing velocity in an increasing temperature, whilst in a decreasing temperature they must recede from the centre with a gradually diminishing velocity. In the engraving, the rim is composed of a lamina

Hartnup's Balance.



of brass and steel, united as in the ordinary balance, the steel of which is bevelled or turned at an angle of 45° or thereabouts. The bar *a*, *a*, with the bars *a*, *b*, *a*, *b*, and also the bars *b*, *c*, are composed of brass and steel united as in the rim; *a*, *a*, has the brass uppermost, and *b*, *c*, *b*, *c*, have the steel uppermost, and they are firmly joined at *b*, *b*. The compensating weights slide upon the rim as in the ordinary balance. Now the effect of the inclined position of the rim is this:—The different expansion of the two component strips, carries the weights to and from the centre, and also up and down in a slanting direction, owing to the bevelled form of the rim. The slant takes off from the action of the rim, but this is increased to the proper amount at mean temperatures by setting the weights more forward, so that the balance is compensated for small changes. So far the new construction acts exactly as the ordinary compensation balance. To show how the balance acts in extreme temperatures, first take the case of extreme heat—the ends of the bar *a*, *a*, bend downwards, and the ends of the bars *c*, *b*, curve upwards; and the compound effect of these two curvatures is to set the bevelled rim more nearly perpendicular to the plane of the balance, whence the effect of the compound rim in bringing the weights towards the centre is greater than it would have been in its more inclined position. Now, this tends to shorten the time of vibration the balance. In the ordinary construction, a chronometer loses in extreme heat; the new construction, therefore, tends to compensate the losing rate in extreme heat. Again, in extreme cold, the ends *a*, *a*, bend upwards, and the ends of *b*, *c*, *b*, *c*, bend downwards, from the unequal contraction of the brass and steel strips which compose the bar. The effect of this compound action is to set the rim flatter or more nearly parallel with the plane of the balance. Hence the effect of the compound rim will be less effective in removing the weights from the centre than in the ordinary construction, and the balance will move more quickly. A balance of the ordinary construction loses in extreme cold, hence the new balance tends to compensate the error.

Mr. Hartnup found by experiments that chronometers furnished with the new balance are sufficiently compensated in all degrees of heat and cold, and for a proof of which tables are given containing the rates of three chronometers to which these new balances were applied. The temperature ranging from 31° to 105°, the chronometers were tested for two months in mean and extreme temperatures of heat and cold, with scarcely any variation. These three chronometers were afterwards tried at Greenwich, and one of them (No. 228, Wm. Shepherd) was purchased by the Government. The chronometer by Hornby, in 1857, was tested in temperature from 21° up to 105°. In 1858, a chronometer by Blackie headed the list, with a new auxiliary compensation (description unpublished); and two chronometers with Poole's auxiliary compensation stood second and third, with a range of temperature from 23° to 95°.

In 1859, a chronometer by Campbell, of Liverpool, stood top of the list, with an unpublished alteration of the balance, Frodsham and Baker second, Crisp third, with a range of temperature from 31° to 105°.

In 1860, a chronometer by Birchall stands first, with an alteration of the balance (unpublished), W. P. Birchall second, Muirhead, with Poole's auxiliary, third, with a range of temperature from 25° to 100°.

In 1861, McGregor, with Poole's auxiliary, heads the list, Webb second and third, with an unexplained auxiliary to the balance; a range of temperature from 27° to 104°.

In 1862, two chronometers with Kullberg's balances, the first one bearing the names Simpson and Roberts, the second one the name of the maker, Mr. Kullberg, the third, fourth and fifth chronometers were with Poole's auxiliary compensation; range of thermometer 21° to 104°.

In the year 1863, a chronometer by Fletcher, with auxiliary compensation, heads the

list, Kullberg second, Webb third; the temperature ranging from 38° to 97°.

In the year 1864, a chronometer by Kullberg first, McGregor second, with Poole's auxiliary; range of temperature 32° to 97°.

In 1865, a chronometer by Webb first, Lister and Son second, with Poole's auxiliary, Dent third; temperature 32° to 100°.

In the year 1866, a chronometer by McGregor stands top of the list, Cairns second, Poole third, all with auxiliary compensation; temperature 31° to 101°.

In 1867, a chronometer by Sewell heads the list, Gowland second, with auxiliary compensation; range of temperature 30° to 95°.

In the year 1868, Birchall first, Fletcher second, with auxiliary compensations; temperature 36° to 96°.

In the year 1869, Fletcher first, Whiffen second; range of temperature from 39° to 100°.

In the year 1870, a chronometer by M. F. Dent heads the list, Chittenden second; temperature 33° to 95°. The small error of M. F. Dent's chronometer, in this year of trial, was noticed by the Astronomer Royal to have been the finest chronometer that had ever been on trial, it having made but the small error of 5·5 seconds as the difference between the greatest and the least, and 3·8 seconds the greatest difference between one week and the next, during a range of 62°. No description of the balance having been given in the published rates, the writer supposes it to have had a balance similarly constructed to the one exhibited by this firm at the Exhibition of 1862, of the following description:—M. F. Dent's new compensation balance, with outside auxiliary bows made much thinner than the ordinary lamina of the balance, the steel being outside and the brass within, reversing the metals for the auxiliary compensation-pieces or bows; this gives an increased error which the primary compensation is intended to compensate. The general effect of the balance is that the compensation power is greatly increased in high temperatures. The outside bows are quite free from bankings or check pieces acting upon the balance, which is the principal objection to compensation-pieces.

In the year 1871, a chronometer by Charles Frodsham heads the list, with a new reversed balance, performing very nearly equal to M. F. Dent's chronometer in the previous year; temperature ranging from 36° to 94°.

In 1872, a chronometer by Kullberg takes the first place, with a flat rim balance without auxiliary, Hennessy second, McGregor third; these two chronometers having auxiliary compensation to the balance. Temperature 44° to 95°, a range of temperature of 51° only.

In the year 1873, a chronometer heads the list by Wiechert, with Kullberg's flat-rim balance without auxiliary, showing the very small error of 3 seconds during any week of trial, and 5·1 seconds as the greatest difference between the greatest and the least. The second was a chronometer by Usher and Cole, Mr. Kullberg's being third; three very fine chronometers! The range of temperature was from 35° to 95°, a range of 60° only.

The balance of Mr. Kullberg is a modification of Mr. Hartnup's and Mr. E. J. Dent's balances, or a very great improvement on the principle of the balances invented by those gentlemen. It is composed of a compensated disc, the rim and centre-bar being all in one piece, thus doing away with the attached centre-bars as in the Hartnup balance, and is so constructed that the weights shall act in a straight line to the centre, and has, up to the present time, performed better than any other chronometer at the Royal Observatory, Greenwich. The range of temperature has of late years not been so great, and this accounts for the beautiful performance of the selected few chronometers purchased. This balance does not *appear* so difficult to make as the Hartnup balance, but it is far harder to construct, and will cost about treble the price of the balance of ordinary construction. How these balances will act in other hands, and in higher ranges of temperature, remains to be seen before it can be said that chronometers with these balances shall surpass all others, as was the case in the last year of trial; the balance with auxiliary compensation performing nearly equal to the first, and surpassing the third chronometer with this new flat disc balance.

In concluding this Chapter, I must say that I can give no suggestions for giving the last delicate finish, to the compensation by any means acting upon the spring, which, for the sake of giving lasting good performance, must, be perfectly free and undisturbed.

(*To be continued*).

[I notice that in Example 2, Chapter II., by a slip of the pen, it is said that by shifting the weights backward they will be "*more* influenced," &c.; it should be, of course, "*less* influenced." I think the error is too obvious to mislead.—W.B.C.]

An Association, with objects identical with those of the Leeds and District Watchmakers' and Jewellers' Association has been formed at Bradford, Yorkshire.

THE SIDEREAL CLOCK AT THE ROYAL OBSERVATORY.

Many Members of the Institute will remember observing this clock on the occasion of our visit to the Observatory. It is fixed to the north wall of the magnetic basement, and was made by Messrs. E. Dent and Co. in 1871. It has a detached escapement, closely analogous to the ordinary chronometer escapement, the pendulum receiving impulse only at each alternate vibration; consequently the escape-wheel and seconds hand move only at alternate seconds, the even seconds being in this case selected. The Astronomer Royal reports that the rate of the clock is so steady that the barometric inequality (for the correction of which no satisfactory contrivance could be arranged) is indicated with the greatest regularity, the losing rate of the clock being increased three-tenths of a second for an increase of one inch of barometric reading. It is rather a remarkable fact that this escapement was proposed for clocks by the Astronomer Royal himself, and a description of it printed in the Transactions of the Cambridge Philosophical Society forty-seven years ago. In spite of its excellent performance, however, the increased cost of construction will probably prevent its extended use. The pendulum is compensated by a zinc tube resting on the rating nut upon the steel rod, the zinc tube being in its turn encircled by another tube of steel, resting at its upper end upon the zinc tube and carrying upon its lower end the cylindrical leaden bob, slots being cut in the outer steel tube, and holes made in the intermediate zinc tube, with the object of exposing equally all parts of the compound pendulum rod to the action of temperature. The compensation is, in fact, upon the same principle as the Westminster clock, but that the bob is of lead and is attached at the middle of its length to the outer steel tube. Sir Edmund Beckett, in his treatise on clocks, mentions suspending the bob in this manner, but sees no advantage in it, as allowance can be made for the expansion of the bob when resting upon the bottom of the outer steel tube. But the advantage of attaching the bob at its middle lies in another direction. It appears clearly unwise to rely upon the expansion or contraction of the bob as an element of compensation, for its greater thickness would prevent the effect of any change of temperature being observed so soon as upon the rod and tubes; and although this sluggishness of the bob may cause no appreciable error if the range of temperature is small, as no doubt is the case at Westminster (where the pendulum is enclosed in a chamber) and in the magnetic department of the Observatory where the sidereal clock is fixed, the safer plan seems to be to render the bob as neutral as possible.

The pendulum originally fixed to the clock, which was of the ordinary mercurial kind, was abandoned in favour of the zinc and steel compensation with what we will call the neutral bob, because, when tested with a much greater range, and more sudden alterations of temperature than would be experienced in the magnetic basement, irregularities were discovered which were suspected to be due to the want of uniform sensibility of the bulk of mercury and the pendulum rod.

The driving weight of the clock is placed in a separate chamber from that of the pendulum, and bears slightly against the side of the chamber for the prevention of sympathetic vibration.

Upon the crutch axis of the sidereal clock two straight compensated bars (brass and steel) are fixed friction-tight for the final correction for temperature. It is anticipated that by turning the bars into an inclined position, as respects the pendulum rod, the tendency of the weights to move upwards or downwards with increase of heat, according as the steel or brass lamina is uppermost, will give power to correct any defect in the primary compensation. They were, however, at first placed in an upright position so as to be neutral, and no occasion for testing the efficiency of the arrangement has yet arisen, which is perhaps just as well, for we fear the contrivance is a better theoretical than practical one.

The method by which the time of the pendulum's vibration is recorded by means of the chronograph, so that the exact time of astronomical observations may be registered by galvanism, is given fully by Mr. Ellis, in his admirable Lecture on the Greenwich System of Time Signals, published in Vol. VII., but that, instead of the circuit being closed by a wheel on the escape-wheel arbor, as in the transit clock there in use, the present sidereal clock has a pin on the upper part of the pendulum-rod, which presses together the two light springs at the middle of each vibration for obtaining galvanic contact.

The Postmaster-General makes known that packets containing jewellery or watches are, upon arrival at Peru, subject to Customs' Duty, and should not be sent by post. Letters or packets sent by post containing the above-named articles, addressed to any place in Peru, are, by the laws of that country, liable to confiscation.

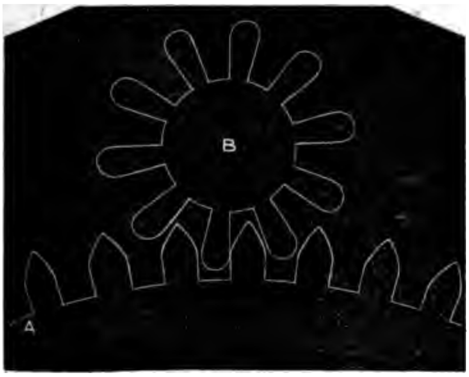
WHEELS AND PINIONS: THEIR SHAPE AND DIAMETER.

By RICHARD LANGE,

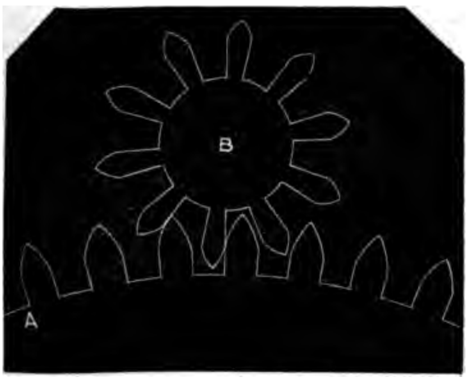
Glasshütte, Saxony.

(Continued from page 14.)

Definition of the drawings.—After having drawn a portion of a circle A, of the same diameter as the brass arc for the primitive diameter of wheel=324$^{cm.}$, and another circle B, for the primitive diameter of pinion =54$^{cm.}$, which touches the wheel-circle in one point; both centres are united by a straight line, the line of centres.



The number of the teeth of pinion must be contained in the number of the teeth of wheel, as many times as the circumference of the wheel contains that of the pinion. In



the drawing the diameter of pinion and wheel are 54 and 324, or=1 : 6, hence the number of teeth in the wheel must be 6 times more than in the pinion, or *vice versâ.*

The number of leaves in the pinion being given, we divide the primitive circle of pinion by this number, commencing at the point where the centre line cuts the two circles, and the wheel-tooth first touches the leaf of pinion. Next, the primitive diameter of wheel must be divided with the same distance or division used for the distance of pinion-leaves, in order to transmit the respective number of revolutions of wheel and pinion in a uniform manner.

The number of leaves of the pinion being for instance 12; having then divided the primitive circle of pinion into 12 equal parts, in setting out from the point of contact (the centre line), we must divide the primitive circle of wheel into the same sized divisions as those used for the pinion-leaves.

Now, after having fastened the metallic arc with the two little pins on the paper (its circumference corresponding perfectly with this circle drawn on the paper), the epicycloidal curve of the teeth of wheel is made by rolling the disc on the arc, the point of the pencil commencing at the point where the side of a tooth cuts the line of the primitive circumference.

For the leaves of pinion no mechanical aids further are wanted, as the radius lines, lines drawn from the centre of the primitive circle of pinion to the circumference, will represent the flanks or sides of the leaves of pinion; the form of the ends being theoretically of no importance.

But though no rounding at all would be necessary at the end of the pinion-leaves, yet my father found that, even when rounded circular teeth are employed, as shown in the first drawing, an alteration of form and gearing will take place, if by the widening of pivot-holes, the depth or pitching becomes too large. In an extreme case, if originally planted rather too wide, the watch will by-and-by become out of order.

For this reason it is good and practical to give the pinion-leaves an olive-shaped form, or the form of a Gothic arch, like the epicycloids of the wheel-teeth. If the depth become too wide an alteration of form will not take place; and in pinions with less than 10 leaves, the first contact of wheel-teeth and pinion-leaves can take place advantageously before the centre line, and will thus give a smooth pitching.

In this way the plans for all pinions from

6 to 20 teeth were drawn with the utmost care; and with regard to the space or play which is necessary between the mutual teeth of wheel and pinion, the sizes for the full diameter, bottom of the pinion, thickness of leaves, &c., were measured, and referred to the primitive or pitch-diameter, which was constantly=54^{cm}.

The thickness of the teeth of the wheel being the same as the space between the teeth, we shall find a good proportion for the thickness of the leaves of pinion, in making them 0·4 of the distance of two teeth or of one division; and the space or clearing = 0·6 of the distance of two teeth.

For instance, divide the primitive diameter of pinion into 12 equal parts, representing the number of leaves, and subdivide each division into 10 equal parts; then four of these subdivisions will give the thickness of leaf, whilst the remaining six will serve for the clearing or space.

In the following I give the measures for some of the pinions with circularly-rounded teeth:—

No. of pinion-leaves.	Full diameter compared to the primitive.	Ground or bottom compared to the primitive diameter.	Thickness of leaves.	Diameter for uneven teeth.
6	65·310 : 54	21·72 : 54	11·31 : 54	
7	63·694 : 54	25·76 : 54	9·694 : 54	60·514 : 54
8	62.482 : 54	28·794 : 54	8·482 : 54	
9	61·540 : 54	31·00 : 54	7·54 : 54	59·698 : 54
10	60·786 : 54	33·00 : 54	6·785 : 54	
11	60·169 : 54	34·38 : 54	6·196 : 54	58·954 : 54
12	59·655 : 54	36·00 : 54	5·655 : 54	

For a pinion of 10, for instance, by this table the full diameter will be = 60,786; the ground or bottom of pinion = 33; the thickness of leaves = 6,785. The primitive diameter in all the columns is supposed to be 54 ^{cm}.

Example.—Suppose we wish to calculate the full diameter for a pinion of 10 leaves, whose primitive diameter = 40$^{cm.}$ then we have to make the simple proportion:

$$54 : 60{\cdot}786 = 40 : x$$
$$x = \frac{60{\cdot}786 \times 40}{54} = 45{\cdot}03^{cm}$$

which is the full diameter for a pinion of 10, whose leaves are circularly rounded.

Though such a proportion is clear and easy to calculate, it takes some time to multiply the second and third figures, and then to divide this product by the first. In order to shorten this operation, we do not take the number 54 for the primitive *diameter*, but 1, and have then for the second figure not 60.786, but 1.126 (as is seen in the next table). When we now make the same calculation to find the full diameter of a pinion with 10 leaves, and a primitive diameter of 40$^{cm.}$, then we have this proportion:

$$\left.\begin{array}{l} 1 : 1{\cdot}126 = 40 : x \\ x = \dfrac{1{\cdot}126 \times 40}{1} \end{array}\right\} \text{equal to 40 multiplied by 1·126, and then divided by 1.}$$

$x = 45{\cdot}03$, as before.

It is clear that we have only to multiply 1·126 with 40 to find what we want, because to divide by 1 would not alter the product at all, and is therefore quite superfluous, and the calculation is of course so much shorter and easier.

We only have in all cases to multiply with the calculated numbers registered in the tables, if the diameter of bottom, thickness of leaves, or full diameter is required; and inversely we have to divide by the values indicated in the second column, if the full diameter is given and the primitive is wanted.

Returning to the preceding example, where the primitive diameter was 40^{cm} for a pinion with 10 leaves the full would be, after the reduction of 54 to 1 for the primitive diameter, $40 \times 1{\cdot}126 = 45{\cdot}03^{cm}$ for circularly-rounded teeth, as calculated before.

In the following two tables we give the said proportions for all pinions from 6 to 20 leaves. Table 1 contains those for circularly-rounded leaves; Table 2 those for Gothic-shaped leaves, whose rounding resembles the epicycloidal form of wheel-teeth.

In both tables we find in the first vertical column the numbers of leaves from 6 to 20.

In the second column the full diameter for each pinion in the first column, the primitive diameter being always = 1.

Thus we find by the side of 10 in the first vertical column the number 1·126 in Table 1, and 1·251 in Table 2.

If, therefore, the primitive diameter is = 1, the full is = 1·126; or if the primitive diameter were = 10, the full will be 11·26 for circularly-rounded teeth.

In the third vertical column we find the diameter of the ground or bottom compared to a primitive diameter which is always supposed to be = 1.

In the fourth vertical column the thickness of teeth in proportion to a primitive diameter = 1.

Not to confuse the calculation, I always refer only to Table 1, as Table 2, for pinions with Gothic-shaped leaves, is arranged in the same way.

TABLE 1.—*For pinions with circularly-rounded teeth.*

I. Vertical Column.	II. Vertical Column.	III. Vertical Column.	IV. Vertical Column.	V. Vertical Column.
Number of pinion.	Full or true diameter.	Diameter of bottom.	Thickness of teeth.	Diameter for uneven teeth.
6	1·209	0·402	0·209	
7	1·180	0·477	0·180	1·121
8	1·157	0·533	0·157	
9	1·140	0·572	0·140	1·106
10	1·126	0·611	0·126	
11	1·114	0·640	0·114	1·092
12	1·105	0·666	0·105	
13	1·097	0·684	0·097	1·081
14	1·090	0·701	0·090	
15	1·084	0·717	0·084	1·072
16	1·078	0·729	0·078	
17	1·074	0·741	0·074	1·063
18	1·070	0·751	0·070	
19	1·066	0·760	0·066	1·059
20	1·063	0·768	0·063	

TABLE 2.—*For pinions with Gothic-shaped leaves, like the epicycloid on the wheel-teeth.*

Vertical Column.	II. Vertical Column.	III. Vertical Column.	IV. Vertical Column.	V. Vertical Column.
Number of pinion-leaves.	True diameter.	Diameter of bottom.	Thickness of leaves.	Diameter for uneven numbered leaves.
6	1·314	0·402	0·209	
7	1·270	0·477	0·180	1·206
8	1·235	0·533	0·157	
9	1·209	0·572	0·140	1·173
10	1·188	0·611	0·126	
11	1·171	0·640	0·114	1·148
12	1·157	0·666	0·105	
13	1·145	0·684	0·097	1·128
14	1·135	0·701	0·090	
15	1·126	0·717	0·084	1·113
16	1·118	0·729	0·078	
17	1·111	0·741	0·074	1·101
18	1·105	0·751	0·070	
19	1·099	0·760	0·066	1·093
20	1·094	0·768	0·063	

Commonly there are but the sizes wanted for the full diameters, or inverted, for the primitive diameters only in making new pinions, the sizes for bottom and thickness of teeth will be required.

IN 1560 Tycho Brahe possessed four clocks, which indicated hours, minutes, and seconds; the largest had but three wheels, the diameter of one of them being three feet, and containing twelve hundred teeth, a proof of the imperfect state of clockwork at that period. Brahe also observed irregularities in his clocks dependent upon changes in the atmosphere.—*Curiosities of Clocks & Watches.*

Letters to the Editor.

All Letters to be addressed to the Editor, at the Institute, 35, Northampton Square, E.C.

To the Editor of THE HOROLOGICAL JOURNAL.

CALENDAR CLOCK.

SIR,—I have lately met with an eight-day clock (maker's name "Bowley, London,"), constructed to show the days of the month and months in a peculiar way, but the greater part of the mechanism having been removed, I am at a loss to know how the object was effected. I, therefore, forward two sketches of the dial, hoping that some reader of the Journal may be able to give a description of it.

Fig. 1 is a front view of the dial, in which

the days of the month are shown by a hand round the arch of the dial, and the months on a circle in the centre of the arch.

Fig. 2 is a back view of half the dial, showing the holes, &c., which appear to have

been used for moving the month work. A, is the centre wheel hole; B, B, B, is part of the

fore-plate of the movement; C, the swing-wheel hole; the D's are screw and steady pin-holes, apparently for screwing on springs; E is the same, but around it the mark of a spring having been screwed in is discernable; the F's are screw-holes, probably for studs, two of them in the fore-plate appear intended for wheels leading off from the nut on the hour-wheel; socket G, is a screw-hole and steady pin-holes; H, is a pulley on the arbor, carrying the day of the month hand; I, is the hole through the pulley, having a smaller hole drilled into it from the bottom of the groove, this is perhaps for fastening the line which passed over the pulley; K, K, are two screw-holes, by which a wheel might have been screwed to the pulley; L, is the screw and steady pin-holes for screwing the cock, M, to the back of the dial; N, is the star-wheel of twelve on the arbor carrying the month hand; the teeth numbered 1, are thin, 2, are twice as thick, 3, is three times as thick; it will readily be seen that the 1's represent the long months, the 2's the short ones, and 3, February. O. L. I. A. W.

PALMER'S ESSAY.

SIR,—The speech of our President, at the Mansion House, on the occasion of the Lord Mayor delivering to the successful competitors, the prizes for workmanship exhibited at the Institute, and which called forth some remarks from you in the March Journal, having been mentioned by some of the speakers at the annual meeting, permit me to say I am not disposed to think that those remarks made by the President were done with a view of throwing (as has been stated) cold water upon the proceedings, or that he thought his remarks were in any way damaging the cause of the Institute. May I ask you, sir, who had a better right than our President to express his well-merited remarks on the treatise or essay on the Balance Spring by Mr. Henry Phillips Palmer? Was he too hard on this subject? I myself wonder the paper escaped criticism, or was not more severely commented upon by some of your readers long before it called forth the remarks made by the President.

In the first place, the writer, Mr. Henry Phillips Palmer, states "Mechanics is the science of mechanical forces, divided into two great divisions, viz., statics and dynamics; the former teaches us the conditions of forces when they are balanced in producing rest or equilibrium; the latter treats of motion and how it is effected by force which is un-*balanced, consequently* as the balance-spring owes its usefulness to a force contained within itself by which motion is given to a heavy wheel or balance," &c. Can the writer be aware that the spring itself has no power of communicating motion to the balance, and is the writer also aware that the motion given to the balance is through a train of wheels, and that the impulse to the balance is transmitted by the escapement, and that the spring is, as a controller, or governor of that force so transmitted, and the laws of isochronism are determined by the length of the spring, for giving equal time in the long and short arcs of vibration? What sort of slogging machinery should we get if what is stated by the writer were true? His statement is, if we want to give a motion to a body of a given mass which shall carry it through one foot of space in one second of time, we must find out what amount of of force will do it, and to make the same body pass through two feet of space in the same time, twice the amount of force would be required, and so on. Why, sir, this is such trash, that the commonest school-boy whipping his top would contradict. Let the writer learn the laws of inertia, or the state of matter in rest and motion, and the given laws of mechanics, viz., that what is lost in power is gained in velocity, and that if velocity is to be gained, it must be at a sacrifice of power. By the writer's theory, to produce a certain amount of motion, say, in the balance of a watch, by the force or power of a mainspring; it if will take, we will say, two ounces to produce a quarter of a turn of vibration, it would require four ounces to produce half a turn, six ounces to produce three-quarters of a circle, and eight ounces to produce a full turn of vibration. Was there ever such a theory asserted before? and can anyone wonder at our President's remarks on Prize Essays, in the presence of such gross blundering.

Vibrations* which are performed in equal times are called isochronous; and isochronism is the name given to a remarkable property of all systems which are in equilibrium, namely, that when disturbance is given, be the same more or less, the oscillations which take place are all performed in the same time, or nearly, so that any acceleration or retardation is imperceptible. Thus, when a pendulum is allowed to vibrate till it rests, it will be found that there is no perceptible difference between the vibrations of longer and shorter extent, of which any reader may

* This explanation of the word "isochronism" was given by me in a former letter to your Journal: a repetition of it here may be perfectly in its place.

satisfy himself by attaching a weight to a string, and observing the vibrations. But a still better proof may be found in a musical string. The finest ear cannot detect any difference between the pitch of a note made by a smart blow on the key of a pianoforte, and that made by a gentle one, yet a very small difference in the number of oscillations per second would be perceptible, and the amount of disturbance from the position of equilibrium, is twenty or thirty times greater in the first case than in the second, when under two different circumstances the longer space is described in the same time as the shorter. It must be that the force acting in the first case is greater than that in the second, and it is sufficiently known from experience that the more a system at rest is disturbed, the greater is the effort which it makes to return. But in order that there may be isochronism, it is not sufficient that the effort to return should increase with the amount of disturbance, but the increase must take place according to one particular law. This law is as follows:—the force of restitution must be always proportional to the disturbance, so that whatever force begins to act when the disturbance = A, twice as much acts when the disturbance = twice A, and so on for all proportions. That this law does prevail when the disturbance is not great, either absolutely, or so nearly that its error is extremely small, may be proved both by theory and experiment.

The isochronism obtained in the balance of a watch is a perfect matter of adjustment of the balance-spring, suitable to the watch itself, which length having been obtained by repeated trials, the timing then must be done by the equilibrium of the balance. I have no faith in twitching and cramping the curb pins for alteration in position, &c., which is a fallacy and mistake altogether.

In conclusion, may I be permitted to suggest to the writer, Mr. Henry Phillips Palmer, to read and study the laws of falling bodies, and to read the description of Attwood's machine, also to peruse Mr. Hislop's Lectures on Mechanics and Mr. Johnson's Lectures on the Pendulum, as published in vols. III. and IV. of your journal, and then he will be convinced how much his theory is in the wrong, and how deep is the error into which he has fallen, which, if allowed to pass uncontradicted, might have a tendency to mislead many of your younger readers.

I am, sir, your obedient servant,
ONUS PROBANDI.

JOHN HARRISON'S GRAVE.

Sir,—A proposition is before the parishioners of Hampstead to enlarge their parish church, which, as they are advised by Mr. Cockerell, can be done "without encroaching upon the graves." Some of your readers may not be aware that Harrison the chronometer maker is buried on the south side of the church (supposing it to lie east and west) close to the footpath, and certainly within the disturbed area, if the proposed addition be carried out.

May I hope that some member of the Institute residing in the neighbourhood will undertake to see that no violence is done to Harrison's grave, the inscription on which, by the way, will soon become illegible?

Your obedient servant,
R.

SAVAGE'S ESCAPEMENT.

Sir,—Referring to my letter on this subject in the September number of the journal, in the first sentence the word "lever" should have preceded the word "escapement; and if, in the second paragraph, the word "velocity" be changed for the words "rapidity of action," it will better express my meaning.

Yours, &c.
E. STORER.

Sir,—I am glad to see in the journal for September that our old friend Mr. Storer still takes an interest in what is going on in Clerkenwell.

He kindly takes notice of the paper read by me at the Institute on the 17th June, and does not agree with me in the remarks I made on the lever and roller action of the so-called two pin escapement, invented by G. Savage.

The substance of Mr. Storer's remarks amounts to this:—That with a 15° pallet, the objections raised against the two-pin escapement do not apply, but with a short-angled pallet the fault of abutting against the opposite corner of the notch, if not made wider than otherwise necessary, will occur.

In the description he gives of an escapement which he once had in his possession, made either by G. Savage or his brother, he says the remarks I made about abutting do not apply. Perhaps not, but why? Because the escapement Mr. Storer describes had I pallet of 15°. In that the whole secret lies.

As Mr. Storer does not find fault with the adoption of such a large-angled pallet, which, of course, enables one to alter the proportions between any kind of lever and roller; must come to the conclusion that he has a

not had any experience about its performance in the watch for any length of time, otherwise he would have found that the 15° pallet would require oiling every six or twelve months to make it go at all with a moderately strong mainspring.

I feel certain, however, Mr. Storer must know, from the performance of watches with large-angled pallets in general, always speaking of an escape-wheel with 15 teeth, that such pallets are not to be recommended, for reasons which I have given on page 162 of the Horological Journal of July, therefore his conclusions about "misunderstood principles" do not apply to my paper. He will no doubt see that the advantage of shorter lever and larger roller in the escapement he has described is obtained by sacrificing two other advantages. In the first place, the unlocking resistance would be much greater so as to cause the balance to set on the locking, with a light balance. In the next place, the friction on the impulse-plane would be increased so as to cause the balance, if heavy, to set on it. Further, the necessity for oil would be increased, so as to require its more frequent application. It is well for the reputation of the English lever watch that a 15° pallet is indeed almost an "imaginary" one, and the shorter-angled pallet the one of general adoption. Escapement makers know the disadvantage which a 15° pallet has over the shorter one: such pallets are never used by them. In fact escapement makers, who have been engaged in making two-pin escapements for a great many years, and only high-class work, inform me that they never saw such a pallet as Mr. Storer describes, and that the remarks which I made about abutting, under such circumstances as mentioned in my paper, are quite correct.

I have no doubt we shall all agree as to the "sound principles," but another thing is to agree as to which principle is the sounder of two that come into collision with each other, and there experience can alone guide us.

In the improvements I have described in my paper I have been careful not to "tamper" with any sound principle.

W. G. SCHOOF.

99, St. John Street Road.

To Correspondents.

I am much obliged to W. Makepiece Howe, *for the complete and perspicuous reply to my question. Only two small items require a word of explanation. What is wheel metal? Is the burnisher for the pierced wheels, as bought at the tool shops, fit for use? I shall be glad of information as to the entire procedure of making a new roller, with a description of the tools required. I understand the size it should be.—P. E.*

R. Hope Atkinson.—*As far as we can judge from the information given, the watch was probably made not long anterior to the date on the mainspring (1707), and is not of much historical value. The maker, "Richard Rooker," was not a celebrity; the name is new to us.*

E. L. May. Defiance U.S.—*Thanks for your letter. At present no diplomas are issued.*

J. D.—Of course after cleaning, when going to time, the index of a Geneva watch should be near the centre of the cock, so as to allow the wearer room for ample adjustment on either side.

A Treatise upon Railway Signals and Accidents. By Archibald D. Dawney, Assoc. Inst. C.E. London: E. and F. N. Spon.

While its title will no doubt ensure for this work an amount of popular attention owing to the alarming frequency of railway accidents, the admirable and detailed treatment of the subject renders it of particular and permanent value to engineers and others interested in the construction of the mechanism necessary for the safe working of railways. Mr. Dawney gives a complete history of signalling apparatus and ascribes the invention of one of the earliest semaphores to that remarkable and versatile genius Dr. Hooke.

Death of Mr. Klaftenberger.

With deep regret we record the death, at the age of 72, of Mr. C. J. Klaftenberger, one of the Vice-Presidents of the British Horological Institute, which occurred on Saturday, September 19th, after a short illness, at his residence, 157, Regent Street, where he had carried on business for many years, acting also as correspondent with the house of Breguet.

Mr. Klaftenberger was a skilful watchmaker, devoted to his art, and possessed of exquisite taste. He was ever willing and anxious to co-operate in any proposition likely to perfect any detail or to advance the trade generally. In him the Institute has lost a great friend. In its early days he took a prominent part in the administration, acting always with discrimination, and has at all times been ready to assist with his purse or advice as occasion required. The first list of Council contains his name, and in 1860 he was elected Vice-President, a position he adorned until his death, which has fallen upon his friends an unexpected calamity.

British Horological Institute.

DRAWING AND MECHANICS.

Introductory Address, *by* Mr. F. J. Britten, *the Director of the Classes, on the re-assembling of the Pupils, Monday,* 28*th September.*

It will not be inappropriate in commencing a new session if, by way of outlining the course of study adopted, I make a few remarks upon the most important points which will engage our attention. The desire of the Council is that the pupils should be taught mechanical drawing, and receive such explanation as may be necessary to enable them to form correct judgments upon questions in which the laws of mechanics are involved. The knowledge imparted here will be of a rudimentary character, avoiding as far as possible all mathematical formulas. It will be assumed that the pupils have a fair acquaintance with the rules of arithmetic; and, happily, in obtaining a sound view of mechanics there are no problems involved that cannot be resolved mechanically as well as mathematically.

The object of mechanical drawing is to express upon paper a certain arrangement of the parts of a machine as they exist in the mind of the draughtsman, in such a manner that any mechanic who is able to read a drawing, as it is technically called, will have conveyed to his mind precisely the same arrangement and proportion in every particular; so that, in fact, he could, if desired, cause the machine, no matter how complex, to be made exactly as the draughtsman intended, even to the selection of the materials to be employed, without one word of instruction or explanation. You see, then, that mechanical drawing is merely a means to an end. The drawing is not made for the sake of displaying any artistic ability, but that the person selected to design the machine may think over, and devise, and arrange all the details, so that when the construction of the machine is commenced, all delay in planning, and waste consequent upon altering the parts after they are made, are avoided.

I am sure you will agree with me, that the ability to produce a drawing of that kind is of almost supreme importance to the mechanic, and yet, I say it advisedly, if we except engineers, the accomplishment is almost unknown in England. Far more attention is paid to free-hand drawing; and when mechanical drawing is taught, it is rarely carried beyond reproducing one drawing from another, perhaps altering the scale to which it is drawn, the study probably culminating in the production of an isometrical perspective gorgeously coloured, looking very nice, but being absolutely useless. You see the means has been mistaken for the end. No more application would have been required to enable the pupil to produce from an intricate model, a plan, an elevation, and a section, than was involved in drawing the useless isometrical perspective.

Suitable copies will be placed before you until your hands become accustomed to the instruments; but after you can join your lines neatly, all time spent upon copies would be wasted, for you may practise from copies for twenty years, and then you would not be able to place your ideas upon paper in the manner I have defined as essential. The real art must be acquired by practice from machines or from models of them. Machines are the better practice, because the eye sooner appreciates the correct proportion of the different parts in the scaled drawing.

Before commencing a drawing, carefully consider the relative space your drawing will occupy on the paper, and draw the centre line of each intended view, that you may not be dismayed when it is half finished by finding the paper short on one side and all the margin on the other; not rapidly with a rush, but, as the drawing cannot be correct unless the centre lines are drawn with exactness, you will grasp the stock of the square with the left hand, and with a moderately hard pencil, sharpened to a long fine edge, something like a carpenter's pencil, held perfectly upright in every direction, slowly trace the required line. And be sure to test whether it coincides with the square, and should the least error occur do not scruple to rub it out.

You will soon observe what views are necessary; for, unless the object to be depicted be a globe, one view alone is useless.

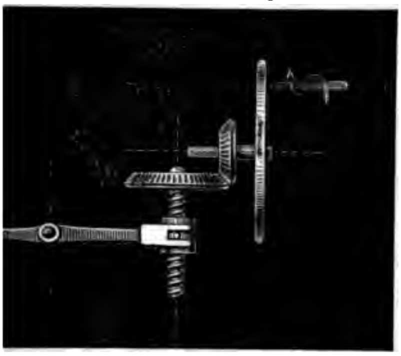
Give two, three, or forty views if essential to the completeness of the drawing, but remember that all unnecessary drawing is waste, not only of your own time, but of the time of all who may have to work from your design. Endeavour, as far as possible, to measure continually from the base or from the centre line, instead of drawing one line first and measuring another from that, and the next line from the preceding, and so forth. There are many points that experience alone will teach you. I fear it will be no use my saying, *Don't* press too hard on your compasses at starting. You will have to undergo the misery of large holes in the centres of your circles before you will pay attention to that. In spite of anything I may say you will be sure to ink in some detail that is hidden by something in front of it, and have to scratch it out, which you will also, no doubt, do with the *point* of a knife, making a kind of gutter in the paper. No warning of mine will save you from the mortification of seeing the appearance of your drawing spoiled at last by patchy colouring, caused by working with a brush too dry or too wet, or by going over one part twice. However, by dint of perseverance and practice you will be able to draw, but if the machine when made is to act as you intended, it must have been designed on sound principles.

POWER IS DEFINED AS FORCE MOVING THROUGH SPACE, AND IS MEASURED BY THE AMOUNT OF FORCE AND THE DISTANCE THROUGH WHICH IT IS MOVED IN A STATED TIME. So that, in considering the amount of power that may be at your disposal, you will always have these two factors—the force, and the speed with which the force is exerted. And the amounts of these two factors are interchangeable, without affecting the amount of the power. There is precisely the same amount of power in 1 pound moved through 20 feet in one minute, as there is in 20 pounds moved through 1 foot in the same time, or the reverse. Indeed, the sole employment of machinery is to alter the speed or change the direction of some motive-power supplied. In no case and by no contrivance can this motive-power be increased, nor can it be diminished or lost. In every piece of mechanism a portion is absorbed by friction or by the resistance of the air; and the skill of the mechanic will be directed to reduce to the utmost extent the amount of power thus withdrawn from its intended use, by selecting, in each case, the mechanical aids best adapted for attaining the desired result. There are various contrivances known to mechanicians for altering the speed or direction of power—the le[ver,] the screw, the inclined plane, and m[any] others. In many treatises on mechani[cs a] few of these are selected, and called mechanical powers, which is an exceedin[gly] unfortunate definition, since power canno[t be] generated by any of them, nor by a c[om]bination of them, nor, indeed, by any mec[ha]nism whatever. Then the principle of eac[h is] often separately discussed, leading to a m[ass] of misleading rubbish about the compara[tive] merits of the screw and the lever, [and] whether the most power is gained b[y a] lever of the first, or the second, or the th[ird] order; with the almost inevitable result [of] perplexing the student, often leading [to] erroneous notions, and even causing men [to] waste a life of energy and ingenuity [in] seeking for some device whereby they sh[ould] obtain perpetual motion.

Here is a sketch of an imaginary machi[ne] composed of some of the contrivances I ha[ve] named, calculated to convert a pressure [of] 10 pounds into one of 15,360 poun[ds.] Although, if such a conversion were requi[red,] it is hardly probable that this arrangem[ent] would be adopted—it is too complica[ted,] and the travel of the lever must be limited; yet it is impossible to say what would [be] the best arrangement, unless every circu[m]stance connected with the work were pla[ced] before one for consideration; so that, you s[ee,] talking about the relative advantages of t[he] lever and the screw in the abstract is simp[ly] wasting time. The judicious arrangem[ent] in any given case will ever depend upon t[he] common sense and experience of the design[er.] If it were likely to be of any real ben[efit] to you, I would give you a separate rule f[or] ascertaining the effect of interposing e[ach] one of them; but the principle of all bei[ng] the same it is not only unnecessary, b[ut] would be confusing. *Exactly as the force [is] increased so must the speed be diminished,* [or] the reverse. That is the universal law, [no] matter what the medium; and if yo[u] thoroughly understand the subject, inste[ad] of being helplessly dependent on rules whi[ch] will sooner or later lead you to some ri[di]culous error, you will be able to resol[ve] any mechanical problem that occurs [in] practice in the shortest and most convinci[ng] manner. We will just trace the resoluti[on] of the 10 pounds into 15,360 pounds, a[nd] then, I trust, the whole matter will be cle[ar] to you.

Let the pressure of 10 pounds be co[n]stantly applied to the handle which is attach[ed] to the fly-wheel at such a distance from [the] centre of motion that it describes a circle [of] inches in circumference (that is, at abou[t]

). Now if the pinion have 10 teeth e wheel with which it gears 40, it is



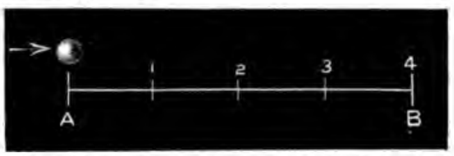
…at, for every revolution of the pinion, …eel and the screw to which you see it …hed will make just one-fourth of a …ion; and, if the screw be a quarter of … pitch, it will evidently move the nut … or downward, but $\frac{1}{16}$th of an inch … quarter of a revolution. Let the …e of the end of the lever attached to …ew be from their common centre twice the end marked with the arrow. It (circumferences of circles being to …her as their radii) that while the long …ll move through $\frac{1}{16}$th of an inch the …nd will move through only $\frac{1}{32}$nd of …h. Now the handle in making one …ion passes through 48 inches, so …$\frac{1}{32}$: 48 : : 10 pounds to x, or to 15,360 . Now, suppose the handle make revolutions per minute, $16 \times 48 \times 10 =$ …units of power. And while 7·680 …f power are exerted at the handle, $\times 15{\cdot}360 = 7{,}680$, or exactly the same … of units are evolved at the short the lever. So that power has been gained nor lost.

… machine has hitherto been purely …ical; the parts have been considered …o weight and the bearings of no size. … and other retarding influences have …e considered.

…ion is defined as the resistance expe- when one hard body is rubbed upon …, caused by the tendency of the aspe- …hich exist on all surfaces, however polished, to interlock, together with …ural attraction which bodies have for …er, and possibly some electric action. …dency to interlock is observed to be …ong when both surfaces are of the …aterial, and is greatly reduced by …ing substances whose atoms are dis- The force necessary to overcome varies directly as the weight or … with which the bodies are kept in is quite independent of the amount of surface over which the weight or pressure is spread, and is unaffected by the velocity of the motion (that is, within reasonable limits; were exceptionally violent motion induced probably the atomic attraction would alter the character of the resistance). Although the amount per revolution or per foot of space passed through remained the same, of course, by doubling the velocity, the *sum* of the friction in a given time would be twice as much. On moderately polished surfaces, such as are to be found in ordinary machinery, it may be taken at about $\frac{1}{10}$th of the weight. It does not vary very considerably whether the surfaces are respectively wrought-iron and cast, wrought-iron and gun-metal, steel and gun-metal, or wrought-iron acting with any of the many patent alloys known to engineers, who in each case select the most suitable material, having in view the cost, pressure, velocity, means of construction, &c. In experiments and in machinery with very finely polished surfaces it has been brought as low as $\frac{1}{60}$th of the weight. If the surfaces are too small in proportion to the pressure, they will be rapidly worn away; and if the disproportion be very great, one or both of the surfaces will be destroyed by abrasion, rendering motion difficult or impossible. With most substances used for the acting surfaces of machinery in motion this abrading action would very quickly develop itself were the surfaces allowed to come into absolute contact, therefore a film of some lubricant is interposed, which of itself has a retarding influence; but in machinery of any size or weight the amount is very small, compared with the friction proper—the attrition of the metallic surfaces. The viscidity of the unguent employed is also proportioned to some extent to the weight; but it is possible to have the weight so small that, even with the most fluid unguent, the adhesion of the unguent shall be far greater in amount than the attrition of the metallic surfaces. In the balance-staff pivots of a watch, for instance, there can hardly be said to be friction at all, the whole resistance arises from the adhesion of the oil, which is exactly proportionate to the extent of the surfaces in contact, instead of to the weight; and as the fluidity of the oil cannot be kept constant, owing to the action of the metallic surfaces and the atmosphere, the varying sum of the resistance is a source of great perplexity, as all watchmakers know. They wisely make the surfaces very small in cases where the greater part of the resistance arises from the adhesion of the oil; but to wilfully reduce the bearing surface when

friction predominates, as is often done in clock plates, shows lamentable ignorance.

Matter, you know, is naturally in a state of rest. The power required to set a body in motion is directly proportionate to the weight, but varies in the same ratio as the square of the velocity; so that, of two bodies of the same weight, but one travelling twice as fast as the other, the one with twice the velocity would have invested in it four times the power of the other. It is not necessary to discuss at length the laws of falling bodies. You are all, no doubt, aware that the force of gravity, although stronger the nearer the earth's centre is approached, may be taken to be practically constant in the comparatively small range through which it acts on falling bodies, and that its force is such that a body attains a velocity of 32 feet during one second—its motion being uniformly accelerated—and that, to attain twice the velocity it must pass through four times the space, that is to say, that gravity, a constant force, requires to act through four times the distance to impart twice the velocity to any body. If any other force be substituted for gravity, the same conditions must be observed, and the power necessary to overcome the inertia of matter must increase as the square of the velocity to be attained. Yet, as a mistake is often made in estimating this quantity, even by those who profess to understand the laws of falling bodies, and as it is of the utmost importance that this should be clearly impressed on your minds, I will beg from you a moment's consideration of this diagram, which will show that the necessity of the power requisite for overcoming inertia increasing as the squares of the velocities, is in exact agreement with our axiom, "that velocity and force are interchangeable."



Let a distance of, say, 40 feet, from A to B, be divided into four equal spaces. If a ball of a known weight require one unit of power to project it through the first space (to 1) it would clearly require another unit of power to carry it through the second space, because all the spaces are equal; and another unit of power would be just sufficient to propel it through the third space, and in fact four units of power would be used in taking the ball through the four spaces. Now if, instead of applying these four units of power separately, the ball be charged with them at the outset of its motion, it will still pass through the four spaces; but the four units of power applied at once will not start the ball at four times the velocity with which it was started by the one unit. For, supposing the initial velocity in the first case to have been, say, 20 feet per second; as the motion had ceased when the ball arrived at the end of the first space, the average velocity would have been equal to 10 feet per second; and if the initial velocity consequent upon applying the four units of power together were 40 feet per second, at the end of one second its velocity would be reduced to 20 feet per second. The mean between 40, the initial, and 20, the ultimate velocity, is 30, so that in one second the ball would have travelled 30 feet, that is to 3, and would still retain a velocity of 20 feet per second, which we have already seen in the first case was sufficient to carry it through one space. So that, although four times the power will only impart to a body double the velocity, the body will, if allowed, travel four times the distance before its motion is exhausted.

There is no more elegant example of utilising the force of gravity than the pendulum of a clock, where the power required to lift the bob when the pendulum is started, is used to carry it to an equal height on the other side of the vertical line; the loss from the resistance of the air, &c., being made up by a slight pressure communicated through the train at every vibration. If this pressure be more than is needed for the purpose, the bob is lifted a little higher each time; or, if deficient, a portion of the power invested in the bob in starting it has to be used each vibration, until the amount of the elements opposed to motion and the power transmitted through the train are exactly balanced. The time of the vibration being governed by the distance between the centre of suspension and the centre of oscillation of the pendulum which determines the steepness of the curve in which it moves.

On account of the power necessary to overcome the inertia, it may be advisable to make those parts of a machine which have an intermittent motion, such as the lever and pallets of a watch and those wheels in the train of a watch or clock that have any appreciable velocity, as light as possible; but where the motion is continuous, the details are usually designed without regard to the power which would be absorbed in overcoming the inertia of the various parts, for the velocity once attained, no further power would be absorbed, and even that used in starting the machine would not be lost, it

would be utilised in keeping the machine in motion after the motive-power was withdrawn.

The resistance to motion offered by the air must be taken into account in some cases. It may be taken to vary as the square of the velocity, and the amount of power necessary to overcome it will be in proportion to the square of the velocity also, if considered with reference to a given space travelled through, but must vary in the same ratio as the cube of the velocity if the amount of power consumed in a certain time be expressed: for instance, if a body be moving through the air at the rate, say, of 100 feet per second, only twice the power would be expended in causing it to move through 100 feet in half a second, as far as the resistance of the air is concerned; but four times the power would be used *per second*, because, you see, the body would move through twice the distance with twice the velocity. We can demonstrate this by the aid of the diagram and with precisely the same reasoning we used in considering the power expended in overcoming the inertia of bodies.

Time has not admitted of my doing more than glancing at the most important heads of the beautiful science upon which your art is based; but I trust that I have said enough to awaken an interest in your minds, and to ensure that, even if you have gathered but little knowledge, you will commence your studies in the right path untrammelled by any false principles or misconceptions.

TOOL FOR CLOSING WATCH HAND-HOLES.

Appended are sketches of a little tool which I find very useful in jobbing; it is for closing the holes in the hands of English watches.

Figs. 1, 2, 3, represent a block of steel of the size shown, hardened and tempered, with a conical shaped hole in it, as I have endeavoured to shew. In fig. 1 the circle in the middle is the top of the hole. Fig. 2 shews how the hole would look if the steel were split down the middle through the hole. There is a slit cut right through from the outside of the steel block into the hole from top to bottom, the outer corners of the slit being bevelled away from each other, as at A, B, fig. 1, which will make those corners look as in fig. 3, C, D.

Fig. 4 is a punch made of round steel wire, and split as shown, with the ends springing open, as E, F. When occasion requires, fix the block in a vice up to the shoulders, G, H, fig. 2, and place the socket (or part with the hole in it) of the hand, in the conical hole, with the end out through the slit; press the split end of the punch firmly down on it, and strike it a few taps with a hammer, turning the punch round a little after every blow. If it is a minute-hand, turn it over and repeat the operation on the other side, this will keep in nearer in shape; if it is an hour-hand, after closing the thick part of the socket in this tool, put the thin part in one of a series of conical holes (they need not be so long a taper) in a steel block; figs. 5 and 6, and strike it with a hammer

thus will both top and bottom of the socket of the hour-hand be closed, and may be made to fit very well.

I have had this tool (except figs. 5 and 6) in constant use about 14 years, and find it answers the purpose very well; it will be seen to be the same in principle as the tool used to make wedding rings smaller or larger. The split punch is used to avoid the necessity for punches of different sizes. This tool will not do for tempered steel hands.

J. VIRGO.

Clock and Watchmakers' Asylum.—The Annual Festival will be held at the City Terminus Hotel, Cannon Street, E.C., at seven o'clock on Tuesday, November 10th, 1874. Mr. E. J. Thompson, Chairman of Committee, will preside.

New South Wales.—Information has been received from the Post Office at New South Wales to the effect that watches and jewellery are no longer subject to Customs' duty on arrival at that colony.

PRIZE ESSAY ON THE COMPENSATION BALANCE, AND ITS ADJUSTMENTS IN CHRONOMETERS AND WATCHES.

(The Baroness Burdett Coutts' Prize.)

BY W. B. CRISP.

(Continued from page 25.)

CHAPTER IV.

It is desirable that a Statement be given of the causes of error, and of the Laws that connect the changes of Temperature with the times of oscillation.

THE cause of error of the compensation balance is simply this:—The balance in heat does not approach the centre fast enough to exactly compensate for the loss of the elasticity of the pendulum spring; and that in cold it recedes from the centre too fast, or does not act in a geometrical ratio to exactly compensate for the spring's elongation by heat, or by its increased elastic force in cold.

The Astronomer Royal, by a series of experiments, in the year 1859, tried upon a chronometer with a plain uncompensated brass balance, by which it was shown that there was an uniform decrease of rate for equal increments of temperature measured by a mercurial thermometer, amounting to 6·11 secs. in 24 hours for each degree of Fahrenheit's scale. I believe no other authentic table was ever published in this country, although the celebrated geometrician, Daniel Bernoulli* conjectured the same in 1747. It was established as a matter of certainty by Berthoud in 1773, with the following result:—One of his marine watches, in passing from 0° to 27° (Reaumur), 32° to 92° (Fah.), it was found that the loss per diem by—

	Seconds.
Expansion of the balance was .	62
The loss of spring's elastic force.	312
Elongation of the spring......	19
	Min. Secs.
Secs. 393 or	6 33

By a study of the table published by the Astronomer Royal, it will be seen that the error is the same with an uncompensated brass balance of 6·11 seconds for every degree of temperature. The change is regular and uniform, passing through heat, cold, and intermediate temperature. Many watch-makers are not aware of this great error of 6·11 secs. in 24 hours for every degree of temperature in a watch with an uncompensated balance; and before commencing the adjustments of a chronometer or watch, it will be well to consider the amount of error to be compensated for in a range of temperature of 60°, which is 6¼ minutes; and this error the ordinary compensation balance will correct to within $\frac{1}{10}$th of a second for every degree of temperature. From what has been stated in the former Chapter, the error has been shown to be 6 seconds for 60° of temperature. This error, strictly speaking, does not take place in geometrical progression, nor will the error be so much as one second for the first 10 degrees, but its error is thus:—

	Seconds.
For 10°	0·3
,, 20°	1·2
,, 30°	2·7
,, 40°	4·8
,, 50°	7·8
,, 60°	10·8 or 36

times the amount of the first error of $\frac{3}{10}$ths of a second for 10°, and so on increasing as the square. But by compensating the balance and dividing the error, the following results will be given by a chronometer timed in 60° range of temperature—

		Seconds.
At 90°	=	0·0
,, 60°	×	2·7
,, 30°	=	0·0

and on the other hand, the performance of the same chronometer with all the error carried over to the cold, will be

		Seconds.
At 60°	=	0·0
,, 90°	=	0·0
,, 30°	=	6·1

thus proving the error to arise through the balance altering its form by the elongation of the arm by heat, and the shortening of the same by cold, carrying with it the rim; thus altering its shape, and not remaining a true or a perfect circle under all changes of temperature. The balance by its proper adjustment can be made to go accurately at two points of the thermometer, but at no other as seen by the diagram Fig. 1. The

* C. Frodsham on "The Isochronism of the Balance Spring."

arcs of the balance, being composed of brass and steel, are so affected by heat as to curve inwards, carrying the weights upon them nearer to the centre, and thus diminishing the effective diameter of the balance at the same time that the strength of the spring is relaxed. But the centre of gravity of these arcs does not approach or recede from the centre in a straight line. Excess of curvature would cause each arc to take a spiral form; and in some positions the weights approach to or recede from the centre faster than in others. Hence it is found that as the arcs straighten outwards, the amount of movement increases in a greater degree than the spring becomes strengthened. If we connect the centre of gravity of the compensation weight with the junction of the arc with the arm of the balance by the dotted line *d*, we shall see that a decrease of temperature, straightening the arc, increases the length of this dotted line. The amount of outward motion is therefore gradually increased as the temperature falls, and with it the inertia, and the chronometer loses. Drawings have been made, and theories asserted; but I clearly claim, by comparison of the tables given by the Astronomer Royal that the real error of the ordinary compensation balance is one-tenth part of a second for every degree of temperature; and that the balance, of ordinary construction is capable of correcting, and does correct, nine-tenths parts of the whole error of 6½ minutes for a range of 60° of Fahrenheit's thermometer.

This is the true cause of error that cannot be compensated for without the addition of auxiliary compensation or check-pieces, or by balances of similar construction to Mr. Hartnup's, Mr. E. J. Dent's, or Mr. Kullberg's—the latter, as before stated, apparently combining the principles of the other two gentlemen's inventions. But in a commercial point of view no balance for general good performance has taken the place of the ordinary constructed compensation balance, which if well and properly adjusted, its error is shown, and takes place as regularly as temperature is indicated by mercury on the scale of a thermometer.

In the works of a chronometer or watch the barrel and fusee revolve so slowly that its motion is quite imperceptible; and through the teeth of this wheel is conveyed the power or force, which puts the whole instrument in motion. Again, the escape-wheel revolves with great rapidity, but with so little apparent power, that a very slight opposing pressure will stop it altogether. Loss of power: from failure of the oil, friction, defective compensation, where will be the fine performance then unless the chronometer has had its isochronal and compensational adjustments carried out to all intents and purposes? The chronometer represents itself to be a time-keeper (with an error, it is true), which can be tabulated with a degree of accuracy almost to determine the longitude within a mile for any distance.

CONCLUSION.

In writing this essay on the Compensation Balance and its adjustments, it has been my object to adhere strictly to the conditions for which the essay was to be written, and to give as much practical information upon the subject as my humble ability permitted. I have carefully avoided all theories and probabilities, and given results obtained from practice and experience. Much has been written upon this subject before, but it has failed to give that practical information intended, and they have been mostly theoretical publications. The chronometer maker looks to the seconds-hand, which tells him its true tale; and how often has this hand denoted the tale of unsuccessful plans, false theories, and great disappointment: if this essay will prevent more of this loss of time and disappointment, my task will have been well fulfilled. In every good chronometer the practical and honest artizan imparts to it a value that cannot be seen, or displayed upon its highly polished surface, or outside case, which are looked upon by *some persons* as a thing of more importance than the intrinsic merit, or unappreciated talent bestowed upon the chronometrical adjustments. The time and talent required in bringing instruments up to the high degree of perfection required for the especial performance of high-class chronometers, such as I have alluded to in Chap. III., is known only to those who devote their practical skill in endeavouring to attain this degree of perfection. Excessive competition and a false endeavour to please the eye have caused many men to lose sight of the requisite adjustments the ordinary compensation balanced chronometer is capable of, and is actually necessary that it should receive. In an honest chronometer the springer devotes his time and talent to isochronal and compensational adjustments, for which he should be paid a fair price—as what labourer is more worthy his hire than the man that really devotes his skill and experience to an instrument whose true purposes are to determine longitude at sea? That this is not done in many instances, the tables given by the Astronomer Royal and the tabulated

tables of the Liverpool Observatory fully bear out my assertion. The adjustment of auxiliary or secondary compensation-pieces requires a degree of skill and care in their management, only to be given by a most practised hand; and will always prevent their becoming generally applied to chronometers; and, as a rule, they are now only applied to chronometers placed on the annual competitive trials at Greenwich; and the performance of many of these chronometers is very bad, whilst the peculiar and difficult construction of balances, which are made with a view of removing the middle error temperature, frequently renders them less permanent in their action, and more liable to injury in the hands of a less skilful mechanic than the maker; far more so than those of the ordinary construction of balance.

Every new experiment made, every new work completed, adds somewhat to our practical knowledge in this department of horology; but so long as the materials we use vary in quality, are wanting in uniformity, and are subject to the changes which moisture, temperature, friction, and other circumstances impose upon them, so long must we remain satisfied by having the errors of chronometers properly tabulated for their variations in temperature; and we must also be prepared to make large allowance for contingencies and variations which do not always readily suggest themselves.

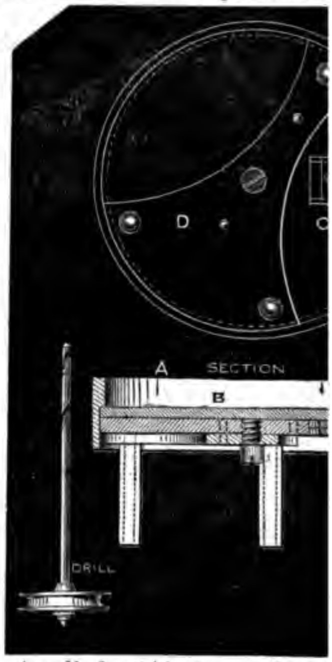
The heavens alone supply the navigator with an unerring chronometer, a time-piece that needs no winding up, that never gets out of order, or needs repair, nor requires readjustment, that can never be deranged by accident, nor be deteriorated by neglect. Placed beyond the reach of sublunary vicissitudes, heat and cold affect it not; storm and tempest may temporarily cloud and obscure its face,* but can neither disturb its mechanism or alter its rate, and we know that it will run down, only when our concerns with time are at an end.

In Japan the twenty-four hours are divided into twelve periods of time, six of which are appropriated to the darkness and six to the light. The day being calculated from sunrise to sunset, there is a necessary variation in the length of the six day and six night hours, the latter being the longest in winter, the former in summer. The clocks are therefore altered periodically to suit the year.

* It is here that the chronometer becomes of such service to the navigator when on the great deep, he relying alone on its performance for his safety.

TOOL FOR DRILLING WA MENTS FOR DIA

Much has been done by Mr. introduce a system of uniformi of the same size; but I have da that his admirable system is n adopted. If I have to make a c hunter, at least 25 chucks are yet if I have a dozen to make require more chucks than to : believe the tool I am about t drilling off movements for dial many instances a convenience decrease the cost of productio



A cylinder (A), recessed as provided for each size of m pillar-plate (B) is inserted. (C), having shifting pieces slid tails, is adjusted to fourth whe drill-holder (D) is now attache the screw and steady pins sh holes drilled to whatever calipe been decided to adopt.

Instead of the pillar-plate being sent to the dial maker, template only; and while the made, the watch may be esca the keyless work fitted. It is in watches made for stock, with thus registered, a named dial n stituted in a few hours by mer the hands. The template alo to the dial maker, the moven intact, and the cost of taking dov

JOHN

WHEELS AND PINIONS: THEIR SHAPE AND DIAMETER.

BY RICHARD LANGE,

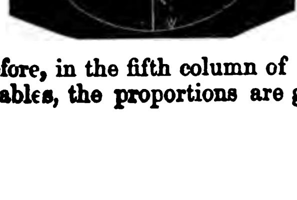
Glasshütte, Saxony.

(Continued from page 29.)

To measure all these parts, and to calculate them without difficulty, my father first introduced (now thirty years ago) the metrical measuring system for watch-work, which has since been used in all our watch and mechanical workshops. It is perfect in theory, and suits well for calculation, because its divisions are quite decimal. 1st. For large diameters we employ the meter-measure, the millimeter being the basis or unit. 2nd. For measuring the height and length, the thickness of smaller parts, and after all the stoutness of sinks, we employ the tenth measure, which in shape and performance is like the Swiss gauge, only the scale is divided into 100 parts, each of them being 0·1 of a millimeter. 3rd. To measure the finest parts, the thinnest and smallest objects, as diameters of pinions and pivots, my father devised and constructed the round micrometer, which indicates the hundredth part of a millimeter, equal to one degree, as it is called here.

These measuring instruments are described already by Mr. Martens and by our celebrated friend Mr. Grossmann in his "Treatise on the Detached Lever Escapement."

By the aid of these instruments all the different sizes of wheels and pinions can easily be measured so long as the teeth are evenly numbered; but it would hardly be possible to measure the full diameter of pinions whose teeth are of uneven or odd number, because opposite to one leaf there is a space, or the points of two teeth are measured on one side, whilst the full tooth is measured on the opposite side. The measured quantity is hence $r + a$.



Therefore, in the fifth column of the preceding tables, the proportions are given for pinions with uneven teeth, as are 7, 9, 11, 13, &c.

The quantity which is to be measured is found either by measurement or by calculation.

By calculation it would be $l = r + a$, and a being $= r \cos a$, $l = r + r \cos a$.

Teeth of wheels.—Having thus found all the proportions necessary for pinions, there only remains to determine the diameter of wheels, which is much easier. The breadth or thickness of each tooth is supposed to be the same as the clearing or space. If thus, my father found that the distance of the primitive from the full radius, or, what is the same, that the length of rounding or epicycloid will be the same as the breadth or thickness of one tooth in any wheel with epicycloidal form,

Hence: Thickness = space = length
or: $a = b = c$

therefore, we have to add one tooth-breadth on each side of the centre, or two teeth-breadth, equal to one distance of two teeth, to the whole primitive diameter, in order to have the full diameter of the wheel.

Having seen that, in finding the full diameter of a wheel, we have to add to the primitive diameter one distance between the points of two teeth, which latter is to be found by multiplying the primitive diameter with π equal to 3·1416 (π, the relation of diameter to circumference is as 1 to 3·1416) in order to find the circumference, and to divide by the number of teeth, in order to get the distance from one tooth to another, or one division. Commonly there need be no such accuracy for the divisions or thicknesses of wheel-teeth, often it will be sufficient knowing it approximately; we find it only on dividing the full diameter by the third part of the number of teeth. If, for instance, the full diameter of a wheel were 16^{cm}, and the teeth number $= 60$;

then the distance of two teeth would be $= 16 : \frac{60}{3} = 16 : 20 = 0{\cdot}8^{\text{cm}}$ nearly.;

Though the accuracy of full diameter will perhaps not often be wanted, I nevertheless give in the following table the values of full diameters, calculated after a constant primitive diameter of 1.

Examples.—If the number of teeth in a wheel, and its pitch-diameter, as well as the number of leaves in the respective pinion are given, now to transmit the force and velocity from the wheel, and the number of revolutions in a uniform manner, we ascertain the pitch-diameter of pinion in relation to the size of its wheel in the following manner:—

The teeth of wheel being 80; the size $= 0^{\text{m}}$
The leaves of pinion ,, 10; the size $= x$

Then we have this proportion:—

$$80 : 10 = 20 : x$$

$$x = \frac{10 \times 20}{80}\ 2{\cdot}5^{\text{cm.}}$$

(The pinion is to be eight times smaller than the wheel, because eight revolutions of the pinion to one of the wheel are desired.)

Now having thus calculated the pitch, or primitive diameter, equal to $2{\cdot}5^{\text{cm}}$, we find in Table 1 the full diameter for a pinion of 10, by multiplying this primitive diameter of 2·5 by 1·1256, which gives $= 2{\cdot}814^{\text{cm}}$; this has to be the full or true diameter for a pinion with circularly rounded leaves.

In order to find the diameter of ground or bottom for this pinion, the calculated value of 2·5 is to multiply by 0·611, which number will be found in the third vertical column of Table 1.

In the same manner we find the thickness of one tooth on multiplying 2·5 by 0·1256, indicated in the fourth vertical column for this pinion of 10 leaves.

Example 2.—If, on the contrary, the full diameter is given, and we wish to know the primitive diameter, it is found by dividing this given full diameter by the number indicated for the respective pinions in the second vertical column. For instance, we know by measurement the full diameter of pinion, and the primitive required. The full diameter is $= 6$ and the number of leaves $= 12$; in the second vertical column we find for the full diameter of a pinion with 12 leaves the number 1·1047. Therefore, the primitive diameter will be $= \frac{6}{1{\cdot}047}$ $= 5{\cdot}43$.

Example 3.—Supposing the primitive diameter of pinion is $2{\cdot}4^{\text{mm}}$, the number of leaves $= 12$, and the number of wheel-teeth $= 60$, and it is required to find the primitive diameter of wheel and the full diameters of wheel and pinion.

The wheel would require to be exactly five times larger than the pinion, because 60, the number of wheel-teeth is 5 times 12, the number of pinion-leaves; for as 60 (the number of teeth) is to 12 (the number of leaves) so is 5 : 1. Hence, the primitive diameter of wheel $= 2{\cdot}4 \times 5 = 12$.

The full diameter of this wheel would be found on adding to the primitive diameter of 12 one distance of teeth. Knowing the circumference (which is to be found by multiplication of the primitive diameter by π) we have to divide by the number of teeth $= 60$, in order to find the distance of teeth.

Hence the distance of teeth will be:

$$\frac{12 \times 3{\cdot}1416}{60} = \frac{37{\cdot}699}{60} = 0{\cdot}628$$

this will be the addenda to the primitive diameter, and therefore the full diameter

$$= 12 \times 0{\cdot}628 = 12{\cdot}628.$$

Approximately we find, as before said, the distance of two teeth, on dividing the primitive diameter by only the third of the number of wheel-teeth, which would be in this example:

$$= 12 : \frac{60}{3} = 12 : 20 = 0{\cdot}6^{\text{mm}}$$

the full diameter would become: $= 12 + 0{\cdot}6$ $= 12{\cdot}6^{\text{mm}}$, instead of 12,628, which will be sufficient in most cases.

In the following table I give the measures for the full diameters of wheels from 10 to 100 teeth. The method of constructing this table is thus:—Calculate or determine the primitive diameter of wheels and its number of teeth, and multiply this diameter by the number opposite to that of the teeth number in the table; and this product will be the desired full diameter.

The calculated primitive diameter of a wheel of 60 teeth be for instance 13^{mm}, hence we find in the table opposite to the teeth number of 60 the number 1·052, by which the primitive diameter of 13^{mm} is to be multiplied. The full diameter therefore is $13 \times 1{\cdot}052 = 13{\cdot}676^{\text{mm}}$; or, inverted, when the full diameter of 13·676, and the teeth number 60 were given, we had to divide 13·676 by 1·052, which again gives the primitive diameter of 13^{mm}.

For the full diameter of wheels from *teeth; the primitive diameter being*

Number of's	True Diameter.	Number of Teeth.	True Diameter.	Number of Teeth.	True Diameter.	Number of Teeth.	True Diameter.	Number of Teeth.	True Diameter.
10	1·315	28	1·113	46	1·068	64	1·0493	82	1·0385
11	1·286	29	1·109	47	1·067	65	1·0485	83	1·0380
12	1·260	30	1·105	48	1·065	66	1·0477	84	1·0375
13	1·243	31	1·102	49	1·064	67	1·0470	85	1·0371
14	1·225	32	1·099	50	1·063	68	1·0462	86	1·0366
15	1·210	33	1·096	51	1·662	69	1·0456	87	1·0363
16	1·197	34	1·093	62	1·061	70	1·0450	88	1·0360
17	1·185	35	1·090	53	1·060	71	1·0445	89	1·0355
18	1·175	36	1·087	54	1·058	72	1·0438	90	1·0350
19	1·166	37	1·085	55	1·057	73	1·0431	91	1·0346
20	1·157	38	1.083	56	1·056	74	1·0426	92	1·0343
21	1·150	39	1·081	57	1·055	75	1·0420	93	1·0339
22	1·143	40	1·079	58	1·054	76	1·0415	94	1·0335
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TURNERS' COMPETITIONS.

nce with the announcement made conditions of competition were specimens of workmanship exe- esponse to the invitation of the Company, were exhibited at the House from Monday, 19th, until 24th of October.

ets of prizes had been offered— cellence of design or workman- in the production of articles of par; the second for lapidaries' ss or gun-metal being the stipu- rial in the third competition.

tering the room where the articles layed, the visitor was at once to the beautiful collection of stone and spar; the size of the specimens in this section ensuring for them due attention. A tazza of serpentine marble, the production of Mr. Frederick George Bradbury, of Penzance, takes the first prize—the silver medal of the Turners' Company, with their freedom and the freedom of the City,—for original design, together with good work. A pair of large vases, also of serpentine marble, attracted universal admiration; the workmanship is unsurpassed, and they are of exquisite contour, but the design is not original; so they are awarded the second prize—the bronze medal of the Company and a sum of money. They are the work of Mr. Christopher Stone, of Lizard, who took the fourth prize in last year's competition; a pair of smaller vases, of very fine outline, taking the third prize—a certificate of merit and a sum of money. These were produced by Mr. John Nankirvis, of Lizard, who took the fifth prize last year. Mr. Nankirvis is further distinguished from the fact that his vases have been purchased by one of the judges. There were also a fine pair of vases by Mr. Pethick; a chalice of fluor spar, shewing great merit, by Mr. Boden; a very creditable flower-stand of alabaster, by G. T. Stevens, an apprentice, aged seventeen; and many other specimens of stone-work, all good. Having in view the number of exhibits, the quality of the work, and the designs where originality has been attempted, the competition in this section must be considered entirely successful, and must have given great satisfaction to the judges, Sir G. Gilbert Scott, R.A., Professor Weekes, R.A., and Mr. W. Vazie Simons.

Although, strictly, lapidaries' work is not turning, there is no industry to which the Turners' Company could have offered their prizes as an incentive to perfection with better effect; nor could the time have been more fitly chosen. Just now the art of diamond polishing, so long monopolised by the Dutch, is being revived in England: and contests, such as that of which we are speaking, are exactly calculated to awaken a spirit of emulation and rivalry among the apprentices. The lapidary work was divided into four classes, according to the material worked upon and the character of the work. In Class A (ruby, sapphire, emerald, spinel) Mr. Fred. Garritt, an apprentice, aged 19, secures the place of honour, taking the chief prize for lapidary work—the silver medal of the company and the freedom of the City; Mr. R. C. Nochold wins the second prize—a certificate of merit and sum of money; and Mr. John Gorsuch the third. In Class B (topaz, aquamarine, crysolite, jargoon, amethyst, rock

crystal, garnet, peridot) the first prize—a bronze medal and sum of money—falls to Mr. Alex. Wallace, for a faceted crystal locket; the second to Mr. Nochold, the third to Mr. Alex. Watts. In Class C—seal-stones, carved garnets, turquoise, onyx &c.), Mr. Vincent Albertoldi secures the first prize, —a bronze medal and sum of money, for his remarkably fine shell and cross of carbuncle; and Mr. Henry Giles Spencer the second, for carved onyx shell, bow, and flower, of great beauty. The exhibits of Mr· Albertoldi and Mr. Spencer have been purchased by Mr. Hunt and Professor Tennant, two of the judges for the lapidary work, a mark of appreciation, gratifying to the artists and their employer, Mr. Ford. In Class D, (diamonds) Mr. Snoek takes the first prize, a bronze medal and sum of money. Mr. John Parsons, who wins the second, and Mr. Alex. Watts, who takes the third prize in this section, are both in the employ of Mr. W. Ford of Red Lion Street, by whose energy diamond-cutting has been established in Clerkenwell as an English industry. Mr. Ford's workmen have entored into the competition with spirit, and carry off many of the prizes awarded for lapidary work. The judges for this section were Mr. John Hunt (Messrs. Hunt and Roskell), Mr. James Norman Foster, and Professor Tennant.

The show of turning in brass or gun-metal was very meagre. Mr. Thomas Rossiter, of Bristol, takes the first prize for a pair of tazzas, of gun-metal, and a model of a steam-engine of the table kind. Mr. William Bickle, of Wandsworth, secures the second prize for a binocular microscope; and the third prize falls to Mr. Cohen, for a watch-stand of brass. The fourth prize is given for a brass candlestick and a vase, both very poor in design and execution. The judges for this section were Mr. S. Jackson of Red Lion Street, E.C.; Mr. J. H. Evans of 104, Wardour Street, W.; and Mr. H. Porter of Cary's, 181, Strand. We were astonished and disappointed to learn, that with the exception of the watch-stand shown by Mr. Cohen, not one specimen of turning in connection with watch or clock-making was sent for competition, due unquestionably to the busy state of the trade; in every branch manufacturers experience the greatest difficulty in getting their requirements met just now. However much the cause may be a matter for congratulation, we still regret that horologists were so poorly represented.

The prizes were distributed by the Lord Mayor at the Mansion House, Monday, 26 October.

THE SIDEREAL CLOCK AT THE ROYA OBSERVATORY, GREENWICH.

Will you allow me space to supple ment the account of the Greenwich Sidere Standard Clock, given in the October numbe of your Journal, by the following particular In addition to what is there already men tioned, the clock possesses a contrivance fo altering its rate by very small amount without stopping it. A small weight, slidin on the crutch-rod, can be raised or lowe by turning a nut at the crutch-axis. A thi steel spindle passes from the nut downward parallel to the crutch-rod, through the smal weight which is tapped to receive the scre cut on the lower portion of the spindle Thus, by turning the nut, the position of th weight on the crutch-rod is easily change and the clock-rate adjusted to any desire nicety. It is to be remarked that a give shift of the weight produces the same amou of change as if it were at the bottom of th pendulum, but in the opposite directio The arrangement might be applied wi advantage to any astronomical clock.

Further, as regards the barometric inequa lity, the Astronomer Royal has now arrange a plan for its correction, which has bee applied to the clock by E. Dent & Co., an appears to fulfil the desired object. It i founded on the magnetic principle, long pre viously in use in the Observatory for dail correction of the Mean Solar Standard Cloc (as described at page 90 of Vol. VII. of th Journal). Two bar magnets are fixed ve tically to the bob of the clock pendulum, on in front, the other at the back, but wit their poles in opposite directions. Belo these a horse-shoe magnet, having its pole opposite to those of the pendulum-magnet is carried transversely at the end of one ar of a horizontal lever; the extremity of th opposite arm being attached by a vertic connecting rod to a float in the lower leg o a syphon barometer placed in one corner o the clock-case. The rise or fall of the prin cipal barometric column raises or depresse the horse-shoe magnet; and, increasing o decreasing the magnetic action between and the pendulum magnets, correspondingl influences the rate; the apparatus being, b experiment, adjusted so that the chang produced shall compensate for the previous observed disturbance of rate.

WILLIAM ELLI

Royal Observatory, Greenwich.

etters to the Editor.

; to be addressed to the Editor, at the
ute, 35, Northampton Square, E.C.

itor of THE HOROLOGICAL JOURNAL.

ISOCHRONISM.

[perceive "Onus Probandi" under-
ıe principle of isochronism; and
l not think it too much trouble,
take it as a great favour if he would
what way the mechanical power of
whirling a balanced wheel around
ıxis, by a small leverage through
angular spaces, is analogous to the
ıl principle he speaks of.
is no occasion to bring watch-work
question, because it is not a subject
l to watchmaking; if the analogy
roved, the fact will exist if watches
xist, and would be applicable to the
balanced wheel ever made, when
by a spring, as well as the most
ve balance put in a watch. It would
dvisable to leave friction and atmo-
resistance out of the question, so as
ıe the subject to pure isochronal
s.

Yours, &c.
UNIQUE.

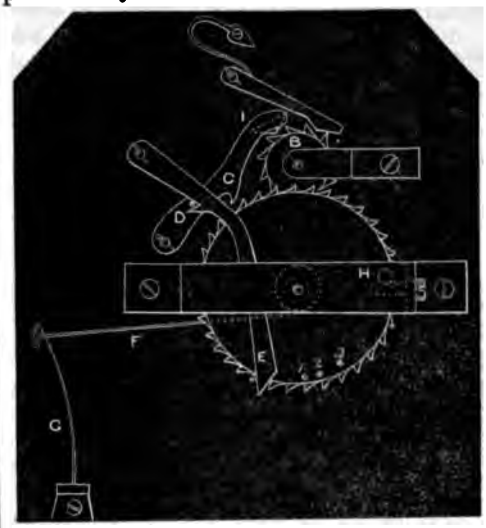
-In the course of a criticism of
; Essay in the October number of
nal "Onus Probandi" says, "the
isochronism are determined by the
f the spring for giving equal time in
; or short arcs of vibration." Will
ur the readers of the Journal by
he length of spring possessing that
', or how such a length can be ob-
He also states that "the timing
en be done by the *equilibrium* of the
." Perhaps "Onus Probandi" will
fine what is to be understood as the
brium" of the balance by which the
s to be done.

I am, &c.,
F. E.

CALENDAR CLOCK.

The clock mentioned by "O.L.I.A.W."
October number is a perpetual diary
y simple and effective kind. I have
net with but one. On the dial is
d "Graham's Successors, Barkley
lley, London." As Graham, the inventor of the dead-beat escapement, died in 1751, it is doubtlessly more than a century old. It is in excellent condition. I have personally known it going for forty years, and the diary work is not in the least worn. It is a weight striking clock with dead beat escapement and maintaining power.

The following is a description of the perpetual diary.



On the frame of the clock is a wheel, not shown in the diagram, in connection with the hour-wheel, and revolving once in 24 hours. On one side of this wheel is a pin near the periphery, and on the other side a pin near the centre. The outer pin moves the piece E every revolution, and the inner pin moves the day of the month-wheel A one click also at every revolution. The wheel A has 62 teeth.

In the centre of the wheel A, on the under side, is a small grooved wheel or pulley, on which a piece of catgut F is wound, the end of which is fastened to the spring G, so that when the click C is pushed out of the teeth of the wheel A, the wheel flies round until stopped by the banking. This banking is shown at H, where the dotted pin fixed on the wheel A is pressing against a dotted screw passing through the upright side of the bar. Of course the dotted parts in the diagram are hidden from view. The month-wheel B has 12 teeth, and is moved by a pin projecting from the under-side of the wheel A. In order to simplify the description of the action, we will suppose only one pin to be on the under-side of A. When the banking pin H is resting on the banking, let the pin on the under side of A be 31 teeth from the part where it moves B one click when it comes round to it. The 24-hour wheel now

revolving, its outer pin moves the piece E to the right. This disengages the click, which falls by its own weight into the teeth of the wheel A. In the diagram the click C is shown held up by a pin D, projecting from C, being caught in the notch of the piece E. Therefore when the piece E is moved to the right, the notch is moved away from the pin D, and the click C falls. The inner pin on the 24-hour wheel at every revolution moves the wheel A one click. The arm E is also moved by the outer pin each revolution; but as the notch of E is now above the pin D, it does not come into operation with C until the 31st revolution of the 24-hour wheel, when the month-wheel B is moved one tooth forward by the pin on the under side of A. When the wheel B moves one click, one of its teeth, in passing the wedge-shaped piece I, which projects from the under side of C, moves up the piece C, so that the pin D again catches in the notch of E. The click C now being raised out of the teeth of A, the wheel flies back by the force of the spring G, until stopped by the banking. We will now proceed to the months having varying numbers of days. The wheel B is composed of three wheels superposed on each other, the lowest one has 12 teeth, the middle has 4 teeth for the months of 30 days, and the upper wheel has 1 tooth for February. The wheel A has three pins on the under side, of three different lengths. No. 1 is placed at the 31st tooth, is the longest, and engages the bottom wheel of B. No. 2 is shorter, is placed at the 30th tooth, and works the middle wheel at B, and the pin 3 is the shortest, is placed at the 28th tooth, and engages the upper wheel at B. These pins are on the under side of A, but their rivets are shown on the upper side numbered 1, 2, 3. The three wheels of B are rivetted together as one solid wheel. Therefore the click C is raised, and the wheel A flies back to the first day of the month, according to the number of days in the month, carrying with it the day of the month hand. The month-hand is fixed to the arbor of B. By a simple arrangement leap-year might be provided for.

I remain, yours, &c.,
R. WEBSTER.
Queen Victoria Street, E.C.

SAVAGE'S ESCAPEMENT.

SIR,—As I neither commended nor condemned the 15-degree pallets, Mr. Schoof's conclusion regarding my experience is not strictly logical; reticence is not evidence of inexperience: besides, be my knowledge upon the subject what it may, much or little, it cannot alter the construction of the "gold pin" escapement; therefore, his reflection is irrelevant.

Not wishing to engage myself in a controversy upon a subject which scarcely admits of one, I studiously avoided all comment upon the theories appertaining to escapement making. The only purpose I had in view was to show by a brief explanation that the "gold pin" escapement, as made by Mr. Savage, was not the defective piece of mechanism Mr. Schoof represented it to be. As he has not questioned the correctness of my explanation, there is an end of the matter, so far as my first letter is concerned. However, as Mr. Schoof's reply demands further observations, I will proceed, but with as much brevity as possible.

The theories which are so earnestly pressed upon my attention I have been familiar with many years past, and have experienced their value. I quite understand that "setting" is an effect arising from the use of balances of an improper weight, and I also know, the same effect will arise from a wide escaping arc connected with a "high" train, and a short escaping arc with a "low" train, and also that a defective wheel will prove detrimental to the good performance of an escapement: but why use balances of an improper weight, or why take a wrong way, when the right is so clearly defined?

One cannot enough admire Mr. Schoof's simple and ready way of making a "gold pin" escapement,—use a pair of 15-degree pallets, and all incidental difficulties will be overcome. It is a remarkable discovery, and a seasonable one, as the knowledge of it will prove an acquisition to amateur watch makers of late years born of our Institute.

Mr. Schoof's chief objection to the escapement is the wide angle of the pallets; he should remember that a few years ago wide angle pallets meant wide escaping arcs, so, is Mr. Schoof sure the changing rates of watches under trial (he has had great experience) were not due as much to one evil as the other. Can Mr. Schoof show that the 15-degree pallet, as adapted to the gold pin escapement, is not an exception to the rule, that the 15-degree pallet is bad in principle?

Mr. F. Cole thus expresses himself (Vol. I. HOROLOGICAL JOURNAL), "a steady and permanent time-keeping principle consists in the higher detachment," and therefore that escapement, whatever its construction, which offers least resistance in unlocking, and from this and any other cause allows the motive-

force to produce the greatest amount of vibratory motion of the balance, is undoubtedly best calculated to realise those desirable ends.

The "gold pin" escapement is in strict conformity with these conditions.

But would the thickening of oil upon the pallets derange these time-keeping properties to the extent Mr. Schoof imagines? Consider this question in connection with a pair of 10-degree pallets, of a single pin escapement. In each case the escaping arcs are equal; therefore the wheels must pass the planes of their respective pallets in equal times: but the planes of the one pair of pallets are longer than the planes of the other pair; the compensation for the difference between the two is found in the decreased length of the lever of the long plane pallets, which is equivalent to an increased length of pallet-arm, which proportionably reduces the resistance of the pallets, to the wheel force, and allowing the wheel to pass the planes freely. In the other case while relief is given to the wheel force by a more obtuse pallet-angle, such relief is lessened by a greater proportional length of leverage, which, being equivalent to a short pallet-arm, serves to retard the passage of the wheel over its pallet-planes. I am inclined to think that some difficulty would be experienced (upon trial) in deciding dogmatically, that a change of rate in either the one or the other was due to the thickening of the oil upon the pallets.

Mr. Cole objects to the reduction of the escaping arc by improperly enlarging the radius of the roller; and recommends rather the reduction of the pallet angle. His further remarks upon this particular are so explicit that we must conclude he had not in view the gold pin escapement. His meaning is simply this—having an escapement with an escaping arc of 36 degrees, and pallets of 12 degrees, do not, in making another one, enlarge the roller, in order to reduce the arc to 30 degrees; but instead use pallets of 10 degrees. He makes no mention of the proportionate length of leverage; this must be understood to be three out of four in either case. This is a very different thing from a correct proportionate enlargement of the roller. I introduce the objection, because I am inclined to think Mr. Schoof would "make capital" of it; for he seems to imagine that the "gold pin" escapement, having a wide-angle pallet, must necessarily have, also, a larger roller than one suitable for a 10-degree pallet; but it is obvious that by varying the distance between the balance and pallet-holes, the rollers, though differing in proportion, may be made equal in diameter.

Mr. Schoof's remarks about abutting "under the circumstances he mentions" I have not disputed; they prompted me to write.

My reflection upon Mr. Schoof was not of the sweeping character he represents it to be; the sentence he has misquoted stands thus, — "Mr. Schoof will perceive how entirely he has misunderstood its principles."

Mr Schoof will feel at liberty to reply to this, if he thinks fit; for myself I must decline proceeding further in the matter; but, nevertheless, most cordially respond to his kindly feeling expressed towards myself.

Yours, &c.,
E. STORER.

Sir,—Permit me to make a few remarks on Mr. Schoof's letter in answer to Mr. Storer's lucid description and defence of Mr. George Savage's gold-pin lever escapement. Persons not thoroughly conversant with the principles and exactness essential to its perfect rendering are liable to be biassed by Mr. Schoof's remarks, who, although possibly sincere in what he says on the subject, cannot be accepted as an authority. From the fact that low-angled pallets have been generally adopted, the 15-degree pallet is liable to be condemned (without investigation as to its merits), like the dog with a bad name: but it is a question whether the reduction of angle is not sometimes carried too far. The late Charles Frodsham (no mean authority) published a pamphlet some years ago, in which he states: "I will prove in my next the superiority of the 12-degree pallets over all others;" but whether he succeeded in doing so, I never heard. George Savage was perhaps the best pallet-maker we ever had, at any rate equal to the best at the present time. It was he who introduced the style of finish now adopted in the best pallets; yet he, the inventor of the gold-pin lever, made 15-degree pallets, as being most perfect for his invention, although he made them with lower angles for single pin escapements, showing that it is necessary to consider the requirements of either principle; consequently Mr. Storer is justified in not objecting to the long-angled pallets; for the short-angles are the source of error, in which, the impulse-notch being at a greater distance from the centre than the discharging pins, the point of reception in the notch is carried past the impulse-pin, which, moving slower than the notch, it has left the opposite corner, when the wheel is discharged from the pallet-locking, and pre-

vents it entering freely; hence the necessity for widening the notch to prevent the abutting complained of, the impulse-pin having to drop the width of the notch before it can give impulse, instead of rolling into the notch, as described by Mr. Storer.

Mr. Schoof tells us that an "escapement with 15-degree pallets would require oiling every ten or twelve months to make it go at all with a moderately strong mainspring;" that, with a light balance, it would set on the lockings," while it would set on the planes of the pallets with a heavy one. I will grant that it might do all stated, if made with theoretical and constructive errors too great even for the lever escapement to labour against. If the lever notch is wide enough for two pins instead of one, it might set on the lockings, or with an escaping arc of 50° or 60°, as is frequently the case with Swiss levers, it would set on the pallet-planes; but it entirely depends on the proportion adopted. In a 30-degree escapement with long-angled pallets the unlocking is easier effected, instead of the resistance being greater, as stated by Mr. Schoof. The leverage corrects the apparent error. The increased radius of the roller presents less resistance to the force applied, while the short arm of leverage is more powerful to overcome it. Again the period of transition from locking to impulse is less, and the tooth of the wheel is enabled to glide from one plane to the other without the jerk occasioned by the short-angled pallet, particularly when accompanied by a wide lever notch.

Mr. Schoof next informs us that it is well for the reputation of the English watch trade that a 15-degree pallet is almost an imaginary one and that escapement makers, engaged in making 2-pin escapements for many years, never saw such a pallet as Mr. Storer describes. I can only say that, if so, those workmen are unfortunate, for they never made or saw a perfect gold-pin escapement without one, and the sight of a genuine Savage's escapement would be of service to them, for it is truly said that a thing of beauty is a joy for ever; and such was the production of the Savages, independent of the theory developed, the execution was of the highest order, and far surpassed anything that had preceded it.

In conclusion, I will draw attention to Mr. Schoof's last paragraph, in which he says: "In the improvements I have described in my paper I have been careful not to tamper with any sound principle." I will leave your readers to judge whether there is not grave tampering with sound principles. As for the boasted improvements I have looked for them in vain, and I can only say the watch trade is greatly indebted to Mr. Storer for his gallant defence of Savage's lever.

I am, &c.

J. L. TILLING.

1, Elizabeth Terrace,
Liverpool Road.

To Correspondents.

[*We shall be glad to hear further from* Mr. Fewtrell.]

E. Chaplin.—*We cannot recommend any patent agent; we believe there was something of the kind in the Exhibition of* 1851.

Turret.—*It is true that if you double the diameter of the barrel you will only require half the weight; but do not lose sight of the fact that the weight must have double the fall.*

Horory.—*Harrison's original timekeeper is at the Royal Observatory, Greenwich.*

J. Banks.—*It is impossible to state with accuracy the time when wheel clocks were first invented. Ingenious men of several centuries from Archimedes,* 200 *years* B.C., *to Wallingford, at the commencement of the fourteenth century, have been named as the inventors of the clock.*

G. A.—*You are wrong. Cast iron will stand a far greater crushing force than wrought, and is therefore more suitable, under many conditions, for columns and the like.*

P. Paillett.—*If you will favour us with your article complete, it shall receive our consideration.*

I have lately met with an old verge watch, having gold cases marked with the initial letter h, *three towers, and a thistle. Can you tell me where it was hall-marked and when?*—H.B. [*Edinburgh, between 29th September,* 1813, *and 28th September,* 1814.]

P. E. will find the modus operandi *of making a new roller described in Volume XIV. page* 124.—Silex.

Referring to the question of J. D. *as to whether, after a Geneva watch is cleaned and regulated, the index should be in the centre of the cock: as the watch will always lose when it gets dirty and the oil thick, I think it would be right to leave the index nearer to retard (or slow), say between the screw and the extremity of cock.*—A.D.

F. Allerding & Son, Sydney, N. S. W. *Subscription to December* 1874 *received, with thanks.*

Can any of your numerous readers tell me of the best way of silvering clock dials?—G.H.

British Horological Institute.

[Meeting for discussing Mr. W. B. CRISP'S Essay on the Compensation Balance, held on Wednesday, November 11th, 1874.]

Mr. JOHN JONES, F.R.G.S., Vice-President, presiding.

[T]HE CHAIRMAN said the usual course would [be for] the discussion of the various points [contained] in a scientific paper should be pre[ceded] by the paper itself being read. He [thought] he might fairly assume, however, [that] the members present had carefully [conside]red Mr. Crisp's essay, and they would, [therefor]e, take it as read. He had received [a letter] from a gentleman well-known in [connect]ion with the subject of compensation, [whose n]ame Mr. Crisp had introduced in his [essay, a]nd who, in the course of the letter [which h]e would now read, challenged some [of Mr. C]risp's fundamental propositions:—

[To the] Chairman,

[Sir],—In a country where so much has [been do]ne to perfect the chronometer as in [Englan]d, let us hope that the same striving [after pe]rfection may be devoted to it in future [as has] been devoted to it in the past, and [the tim]e will surely come, in 'spite of the [conten]rily inclined,' when tabulating of com[pensatio]n errors will only be needed for the [che]apest of chronometers. Mr. Crisp's [advice t]o tabulate the errors, although very [good in] theory, I fear will take longer to [achiev]e than a perfect compensation, be[cause t]hat raters of chronometers, as a rule, [and] captains, would have the means, or [would ta]ke the trouble, to follow such advice? [Our ex]perience proves that perfect chrono[meters] are more and more in request, at [consider]ably higher prices; indeed, the ten[dency is] always to get a perfect thing, if it [can be] had. We also notice that, whereas [formerly] (not many years ago) ordinary [chronom]eters were frequently seen on the [Greenwi]ch trials, in spite of the alleged [inutili]ty of auxiliary compensations, no[w witho]ut auxiliaries are found there at [the pres]ent time. This striving after im[proveme]nt is unquestionably owing to the [Greenwich O]bservatory trials, for which all chro[nometer] makers must be thankful. Mr. Crisp [gives a] series of trial numbers for several [years, a] very good criterion of general ex[cellence,] but not sufficiently to the point to [show the] actual state of compensation alone; [nothing,] in fact, can be more misleading, and no man must know better than Mr. Crisp how much acceleration, escapement errors, imperfect adjustments, and bad oil, cause very perfectly compensated chronometers to stand indifferently on the lists. Mr. Crisp mentions several well-known auxiliaries; it would have been well if he had explained more fully the causes of success or failure, because it is upon such points that the general knowledge is deficient; the rough outlines of the methods are generally well known.

"Having arrived at the practical portion of the essay under discussion, I cannot help mentioning one or two little matters. If ordinary chronometer balances were made with the weights to fit, as described by Mr. Crisp, such chronometers would surely not go well; the notches should, on the contrary, not fit, but be of larger diameter than the balance-rim, and be wide enough to permit it to move freely both in and out. In explaining the cause of error of the ordinary balance, Mr. Crisp adopts Mr. Charles Frodsham's reasoning in the Jury Report, 1862 Exhibition. He says it lies in the circular form of the rim, and its imperfect moving of the compensation-weights to or from the centre. Why, may it be asked, does a flat-rim balance, although its rim remains concentric in changes of temperature, and although the weights move direct to the centre, require to move in a curve, and a considerable curve, to boot? Because, if the weights did not move in a curve, but only in a direct line, they would have as great a fault as the ordinary balance, which shows that it does not matter which way the weights move, owing to the smallness of the motion, but that the ordinary balances become more effective the further the weights recede from the centre, and less effective as they approach, thus making it necessary that the weights should move in a curve, in order to obtain a perfect compensation; or, if a balance is not constructed to accomplish this, it must be provided with auxiliary. How many failures have not been made through this erroneous misinterpretation of the facts! Mr. Crisp very rightly says that my flat-rim

balance is a combination of Dent's and Hartnup's balances. So I say; only there is this difference, that none of those balances are solid, nor have they flat rims. The similarity is about the same as Earnshaw's balance made out of a solid block, compared with Arnold's earliest bent laminæ balance, or as between Earnshaw's escapement and Arnold's escapement—both those escapements having 'scape wheels and detents, only that they are somewhat altered.

"To show that the position on the Greenwich lists cannot be taken as a proof of the perfect state of the compensation, I will only refer to an instance of a chronometer of my make, No. 1889, which went through all changes of temperature better than ever a chronometer has done up to the present time for exactly six months, but an error of nearly a second a day in ordinary temperature placed it fifth on the list that year (1869). In conclusion, let me add that if a balance can be made to move in a curve through 30°, 65°, and 100°, Fahrenheit, it will, when perfectly free, as the flat rim, move still further, as I trust Mr. Crisp will be able to see. One of my flat-rim balances, which has been tried at Greenwich, happened once to be in the cold, with the thermometer at 0°, still showing exactly the same rate. I can only regret that the severity of the trials, as in 1862, when two flat-rim chronometers stood at the top, have not been continued, although no doubt the trials, as at present conducted, are more beneficial than very great extremes.

"V. Kullberg."

Any opinion of Mr. Kullberg on the subject of compensation was entitled to consideration. The members would observe that, whereas Mr. Crisp attributed the known error of the ordinary compensation-balance to the fact that the weights did not approach the centre of the balance in a radial line, but curled up, after the manner of a shaving—if he might venture to use such a simile—on the other hand, Mr. Kullberg asserted that if the weights were to approach the centre in a straight line, they would be wrong. There then was fair matter for discussion. He would now invite the members to mention any other point in the essay that required elucidation, or to which they took exception.

Mr. Strachan said that from the excellent performance of Loseby's balance, reported by the Astronomer Royal, he imagined Mr. Crisp would have developed in his essay the principle of its construction. Loseby's balance was almost perfect in theory, and, he thought, might have been adopted in some form, notwithstanding the controversy on its accuracy between the Astronomer-Royal and Mr. Denison. Mr. Crisp had done well in quoting the Greenwich rates, but he would have done better had he referred more fully to the Liverpool system of tabulating the temperature error—a system of great practical value to the navigator, and could be applied to any chronometer. As an instance of its value he might mention that, while he was at the Chronometer Office, Captain David Smith, a member of the Astronomical Society, showed him his rate-book from day to day. The result of Captain Smith's experience was that he was not more than one mile out of his reckoning the whole voyage, instead of 60, as he would probably have been with an ordinary chronometer without the correction for the temperature error. There was really no difficulty in applying the table. He thought all chronometers should be supplied with the table for temperatures of say from 50° to 85°. He was aware that in a voyage to Calcutta, for instance, a higher temperature would be encountered, but the temperature between decks would rarely exceed 85°.

Mr. Crisp, at the end of his essay, led his readers to infer that in cloudy weather the chronometer was of the greatest use to the navigator. That must surely be an error. Greenwich time, as shown by the chronometer, was of no use to the navigator without local time obtained from an observation. Sometimes in rounding Cape Horn they were for eight or ten days unable to take an observation, and, as a consequence, the ships having to be navigated by dead reckoning, they found themselves one, or even two or three degrees, out. Mr. Crisp gave as the total temperature error for 60°, 6 min. 33 secs. He should like to know if that range of 60° must be between fixed points, as, say, between 30° and 90°, or whether the same error would result in a range of 60°, say, 40° and 100°. Would Mr. Crisp also say how he obtained the subdivisions of the error, as given on the table in page 38 of the journal—if by experiment or not.

Mr. Isaac said a feeling seemed to exist that the idea of this discussion was to depreciate the value of Mr. Crisp's essay. That, however, he trusted was not the case. Referring to Mr. Kullberg's letter, there was no doubt the compensation-weights should not be tight on the rims—the notches generally allowed an amount of play equal to one thickness of the laminæ. Mr. Kullberg was also quite right in describing the weight of his flat-rim balance as moving in a curve. The path of the weight was upward and

l, or downward and outward. He it it would be impossible to make a of the temperature error that should to all chronometers—the sum of the was made up of so many elements. A deal depended upon the position of ights. If at the point of flexure of the lose to the arm), an arc were described radius equal to the radius of the e, that arc would cut the centre of the e and the rim, and the point where curve would cut the rim should, in inion, be the position of the centre of eight. No doubt much extra labour be involved in always pitching the s there, but the result would be bene- When the weights were pitched near t in the rim, that chronometer invari- ost in cold. But even though the s were always pitched in the place he ndicated, the alloy of brass and the would not always be of the same com- n, so that to tabulate the error he con- l out of the question.

Bickley said, in reference to a re- of Mr. Isaac, that the supposition of n of the discussion being to depreciate risp's essay was quite wrong.

Glasgow thought that as the selection subject for that evening's discussion ated with him, he should at once dis- all idea of depreciating Mr. Crisp's On the contrary, in suggesting that risp should have an opportunity of an- g any question or meeting any objec- his only anxiety was that no part of ay should be liable to misconstruction. d always felt strongly that the pro- of the institute was to make the prin- of their trade known. He did not er the compensation of chronometers in factory state, and no real improvement ed to him to be made. They had ately heard of ships being lost through tes. Like the painters in going back pre-Raphaelite period for an inspira- hey must go back to some of their old s for an idea. The whole principle of nsation was wrong. Eleven-twelfths total temperature error originate in the , and, instead of unsuccessfully attempt- correct that error by a balance having or of its own, the greater part of the lue to the spring ought to be corrected source. He did not, however, think the final adjustment should be at- d in the spring. That suggestion rom no less a person than the Astro- -Royal himself. Bearing in mind that trivances for correcting the errors of the balance in extremes of temperature were more or less unreliable, and many of them unfit for rough usage, he thought the best plan was that (he believed) first suggested by Mr. Hartnup—tabulating the errors in the ordinary balance. He thought, on the whole, the council might feel satisfied with the result of the action they had taken regarding these essays, and that the interest the trade would feel in Mr. Crisp's essay, and those yet to be published, would enable them to continue their exertions in that direction.

Mr. Strachan considered the trials at Greenwich afforded a true index of the performance of the chronometers when at sea. The English surveys were the most exact of any made. He was aware that Sir Edmund Beckett, the president of their institute, had questioned the wisdom of the method of testing chronometers at Greenwich. He would suggest that the results of the French trials, published in the *Rèvue Chronométrique*, should be reproduced for the benefit of the readers of their own journal. He rather expected a more minute description of Mr. Kullberg's balance in Mr. Crisp's essay.

The Chairman thought that, bearing in mind the various adverse influences against which chronometers had to contend, their near approach to perfection was a matter of congratulation. The idea had often struck him whether the effect of the variations of temperature so apparent upon the balance might not exert an influence upon other parts of the chronometer sufficient to affect its rate. Whether the cock carrying the upper part of the balance staff extending further from its attachment to the plate than the potence which carried the lower end of the same staff, might not tend to throw the balance slightly out of upright, or even to affect the depth of the escapement.

Mr. Crisp, in reply to the remarks in Mr. Kullberg's communication, said that he had never been an advocate of remaining stationary, nor did he in his essay infer that further improvement was unnecessary. Indeed, he had made the compound flat disc as an auxiliary to the balance as long ago as 1859, and exhibited one in the 1862 Exhibition. In answer to Mr. Strachan, one cause of the non-adoption of Loseby's balance was the difficulty in attaching the glass tube containing the mercury. The error of 6 min. 33 secs. was for a range of temperature from 30° to 90°, as stated in the tables given by the Astronomer-Royal. The subdivisions which he had tabulated he had proved by experiment. He agreed with Mr. Isaac that chronometers with the balance-weights placed

near the attachment of the rim with the arm performed well.

He had found a balance cut in the middle, and having double weights, give good time. The reason that he had not more fully described Mr. Kullberg's balance was that he had never been able to procure one. He was fully aware of the great value to navigation of the Liverpool trials and Mr. Hartnup's admirable system of tabulation.

The CHAIRMAN proposed that the thanks of the members be tendered to Mr. Crisp for the practical, modest, and luminous essay he had given them. He thought it was the feeling of the members that the subject of compensation should be further considered at their next meeting, which he announced for Tuesday, the 8th of December, when he hoped many more members who took an interest in the subject would attend.

Gauge for Measuring the Comparative Strengths of Balance Springs.

I HAVE found the gauge shown in the accompanying engravings very useful, especially when it has been necessary to substitute for a spring another of a different size or strength.

Fig. 1 is a view of the back of the gauge. Upon a plate of brass, like a common watch plate, is mounted an arbor, with a balance-spring of medium strength pinned in as

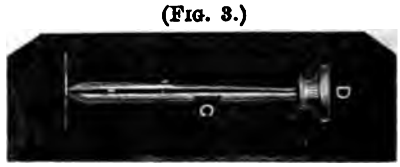
(FIG. 1.)

shown. The projecting nib A is carried round from its point of rest (that is, bearing against the stop, as shown by the dotted lines) nearly a whole turn, when it is prevented from flying back by the catch B. Now, referring to the front view (fig. 2), it will be seen that the arbor is carried through the plate, and has a pointer, resembling a long seconds'-hand, attached to it. A word

(FIG. 2.)

of explanation is now required respecting the little tool (D) represented by fig. 3. The tweezer-like points are kept together, by the spring forming one of the legs, with just sufficient force to grasp a balance-spring tightly. But if both legs are pressed together somewhere about C the points will

(FIG. 3.)



open. With this tool take hold of the eye or inner coil of the balance-spring that has to be discarded. The stout leg of the tool has a hole drilled up it to fit the end of the arbor of the gauge above the pointer. Fix the tool upon the arbor, and, holding the outer coil with an ordinary pair of tweezers (see fig. 2), push the knob E. The nib A being released, the pointer flies back some distance, according to the strength of the spring being tried.

The spot indicated by the pointer being noted, the relative strength of any spring which it may be proposed to substitute for the one discarded may be ascertained with great exactness. The whole operation occupies but a remarkably short space of time, and, in addition to the dial being subdivided into small divisions, it will be a great practical help if the spot indicated by the pointer for every number of springs in general use be marked by corresponding numbers on the dial.

A. DALDORPH.

AN ESSAY ON COMPENSATION,

FOR CORRECTING THE ERRORS IN TIME-KEEPERS ARISING FROM CHANGE OF TEMPERATURE.

BY JOHN GOTTLIEB ULRICH.

From the apparent simplicity of the Compensation-balance, few people are aware of the time that has been devoted to the subject, and of the vast amount of money expended on its production, thus far towards an efficient one, both by public money and private enterprise (in England alone), without the grand desideratum being achieved.

A brief account of its origin, and of the gradual development of the same, with the relation of a few remarkable incidents, from which have emanated some of the most important improvements in the Science of Horology, will, I trust, be acceptable; particularly to the junior branches of the trade.

I therefore propose:—

First,—To draw attention to the state or commencement of the art in the tenth century, and of the slow progress of advancement made thereon.

Secondly,—To point out, or give some account of, what has been done towards its improvement, showing the discovery of the *causes* of error in time-keepers (or chronometers).

Thirdly,—To offer some observations on what I conceive remains to be done.

On the State of the Art in the Early Period.

The first vertical escapement with the usual crown wheel of which there is any authentic record is that made in A.D. 996, by that eminent ecclesiastic, Monk Gerbert, who was raised to the dignity of the Papal Chair, under the title of Pope Sylvester the Second.

In the 11th and 12th centuries very little progress was made (or made known), but previous to 1450 many very beautiful specimens of watch-work (about three inches diameter) were made in Germany with the vertical escapement and alarm work with a double hammer and striking train, with the usual locking-plate; the same precisely as is applied to the ordinary clock at present made in France and Germany.

A heavier balance was needed, and a spring to its axis, but upwards of six hundred and sixty-two years elapsed before the spring was invented, which was done in 1658, and then nearly twenty more before it was brought into a tangible shape and put in practice; which, in the year 1675, was effected for the inventor, Dr. Hooke, by Mr. Thomas Tompion, in a watch made for King Charles the Second.

In it a difficulty of a very formidable nature presented itself, which threatened for many years to prove an insurmountable obstacle in the way of rendering it worthy of the name of a time-keeper.

Dr. Hooke was aware that the change of temperature would alter the strength of springs, hence the necessity of a Compensation (or self-acting regulator), that should act upon the spring on change of temperature.

The making of this thermometrical agent was first attempted by Mr. Tompion, by attaching one end of the principal portion of a circular ring of brass to the regulator of a watch (now known as the curb), having two pins fixed to the other end, between which the balance-spring acted, traversing to and fro from the stud in a circular manner.

In this plan of Compensation there was not sufficient action, and considerable time elapsed before the idea was conceived of obtaining more.

In the early part of the following century, the attention of Mr. John Harrison was directed to the subject with more success.

In the first instance his attention was directed to the production of a Compensation Pendulum, which he effected by a series of nine rods—five of steel, and four of brass—whose "bob," or centre of oscillation, should always be preserved at the proper distance from the point of suspension. It was attached to the centre rod.

He afterwards constructed a Compensation for a marine time-keeper, composed of two slips of brass and steel pinned together, the ends of which opened and closed against the spring near the stud.

In 1715 Mr. George Graham (an apprentice of Mr. Tompion) invented a Compensation Pendulum, which consisted of a glass cylinder, about seven inches-and-a-half high, nearly filled with mercury, placed in a stirrup, attached to the end of an iron pendulum rod.

About the year 1734 many experiments were made by Mr. John Ellicott for obtaining good Compensations. For a watch he applied a curb to act upon the spring near the stud. At the London Institute, Finsbury Circus, there is a clock containing a very beautiful specimen of his new Compensation Pendulum, in which the "bob" is raised by the downward action of the brass rod upon the two adjusting levers on an increase of temperature, and, *vice versa*, lowered for a decrease. For particulars see the Philosophical Transactions of that date, 1734-5.

About that time (or shortly after) the attention of Messrs. Julien and Peter Le Roy were directed to the production a marine time-keeper.

They made several elaborate contrivances of Mercurial Compensation-balances, and one of a simple kind, of brass or steel (similar to that invented afterwards by Mr. Thomas Earnshaw), the particulars of which were published in Paris.

Next came the great Ferdinand Berthoud. He made use of the simple Compensation of Peter Le Roy, but with the addition of his adjustable traversing Compensation-curb, and applied it to his celebrated chronometer, No. 28 (recently in my possession, but in a mutilated state), the particulars of which are to be seen in his voluminous works published in Paris.

The Compensation of Mr. Alexander Cumming was a curb of laminæ of brass and steel pinned together, traversing between friction rollers.

The Compensation of Mr. Thomas Mudge consisted of two slips of laminæ of brass and steel, placed upon the curb of the old-fashioned silver figure, piece slides, the ends opening or closing near the stud.

The Compensations of Mr. Josiah Emery (Charing Cross) were of the same kind in his celebrated watch for Count Bruhl. It is mentioned in the book published by the son of Mr. Thomas Mudge.

In 1775 a patent was taken out by Mr. John Arnold for Compensation-balances; one was effected by a spiral laminæ of brass and steel acting upon two levers to move the weights to and from the centre.

In 1782 a patent was taken out by Mr. Wright (in the Poultry), for Mr. Thomas Earnshaw, for his fused and turned Compensation-balance, since in very general use, without any particular alteration, until a very singular defect was discovered in the principle of it, as well as those of Mr. Arnold, but which was not publicly acknowledged until about the year 1834, when it became manifest that, after an outlay or expense of upwards of £34,560 for reward and purchase of twenty-eight chronometers, and about £50,000 more for observatory expenses thereon, there was not one chronometer among them that would preserve a uniformity of rate under the following moderate changes of temperature—40°, 60°, 80°, of Fahrenheit.

They would lose at 40°, gain at 60°, and lose at 80°, or, in other words, gain at the middle temperature, and lose at each side of the central temperature. This is now an established fact, and admits of no contradiction.

This state of things (and the cause thereof) remained undiscovered until the year 1814.

In the beginning of the year 1813 I had a chronometer under my care that had for many months kept a very steady rate of gaining about two seconds daily; but on every Monday morning there was a discrepancy that could not be accounted for; it being always several seconds too slow. This being a two-day chronometer, and not wound up on Sunday, the correct adjustment of the main-spring was suspected and tried, and the isochronism of the balance-spring examined, when they both indicated that an opposite result ought to have taken place. I then suggested to my master the possibility of some polarity being the cause, as it was kept during the week with the figure VI to the north, and on Saturday night and Sunday with the VI to the south, when I was desired to take the balance-spring off and examine the balance, which I found took up its position as due north and south as a mariner's compass would do. Then the mystery was cleared up, which was speedily made known to the owner, and I received orders for a new balance and balance-spring, as that also was strongly magnetic. Upon telling my master that I need not get a *new* balance and spring, as I could deprive them of magnetism, he did not believe it, but gave me permission to try what I could do with them. Within two hours they were both perfectly unmagnetised. This led to a close examination of several other chronometers—to one in particular, which for some time had been performing very well. At the commencement of the severe winter of 1814 it

was placed on the top of the house, where its performance was so very different from what it had been, that it was brought down into the shop again, where it soon resumed its former rate.

It was then again placed upon the roof, when its performance showed that it was advisable to shift the Compensation-weight back towards the junction of the laminæ by the bar, which was repeatedly done until it was brought to time in the cold, where it performed admirably. It was then brought into the shop again, when it was evident that the weights must be moved forward, previous to the doing of which it was tried in the oven up to 120°, and then it was determined to shift the weights *more* forward than they originally had been, and to bring it to time from 90 to 100, and there to leave it (delivering it ultimately with three rates, at 40, 70, and 100).

After this had been done and brought close to time in heat, it was again placed on the roof in the cold, when it was clearly manifest that it was indispensable that some contrivance must be sought for that should make the weights approach the junction of the laminæ at the bar upon the approach of cold, and recede from it upon the approach to heat, or, in other words, to be made to traverse the periphery of the balance, so that a greater quantity of weight should approach the centre of the balance for an increase of temperature to heat, than what should recede from it upon a change to cold.

This was easier to talk about than to do; but by the beginning of 1817 I had devised the means of doing it, and although it appeared quite out of character to think that anything of the kind would ever be adopted, I felt quite satisfied that I should ultimately simplify the arrangements. I therefore showed my inventions to various persons, all of whom admired the principle, and gave me credit for the idea, although not the slightest hope was entertained by them of my ever being able to bring it into a tangible shape to render it generally practicable.

I therefore directed my attention to the production of an adjustable and traversing curb. One of the accompanying drawings at page 12 will give the reader some idea of the utter hopelessness of the case to all appearance, as regards a balance, but it shortly had the effect of doing some good.

Being still proud of my invention (then so apparently useless), I showed it to Messrs. Brockbank and Atkins, and several others, who smiled at it, although they gave me credit for the idea.

Mr. Langston, the clerk to Messrs. Brockbank and Atkins, communicated my proposed improvements to Messrs. Parkinson and Frodsham.

This aroused the attention of Mr. W. J. Frodsham on the subject of improvements, and induced him in 1818 to address a letter to the Right Hon. John Wilson Croker, M.P., then Secretary of the Admiralty, wherein he represented the important advantages that would result to chronometer makers, and to chronometric science in general, if their lordships should deem it worthy of consideration.

In the year 1821 the Lords of the Admiralty commanded that a public trial should commence. Two proportionate amounts were presented for the chronometers most distinguished for their superior performance. Three hundred pounds for the first, and two hundred for the second best. It was afterwards altered to three premiums of £200, £170, and £130.

"Another, and consecutive trials succeeded for thirteen years, at the conclusion of which their lordships considered that it was useless to continue them any longer, as out of about five hundred deposited on trial, no demonstration of improvement appeared, no model constructed, or any feature introduced by which an accurate chronometer could be constructed, after an outlay of £34,560 for twenty-eight chronometers, independent of about £50,000 more for the expenses attendant upon them at the Royal Observatory."

"But in order to stimulate the scientific chronometer maker still to *pursue* the attempt of obtaining the grand desideratum of producing a chronometer that should keep time in all climates; and as the Act of Parliament, which authorised the reward of £10,000 being paid for the discovery of such an invention as would enable a chronometer maker to produce a chronometer that should keep time within two minutes in the year, was repealed in July, 1828, their lordships were pleased to cause a circular to be issued to all the chronometer makers, from which the following is an extract:—

"'Their lordships being, however, still very desirous of advancing, to the utmost perfection, a machine of such value to navigation as a chronometer, they will occasionally reward any important improvement, either in its principle or construction, by which it may be either so simplified as to be materially reduced in cost, without being deteriorated in excellence, or by which a greater uniformity of rate can be insured with

more certainty under all varieties of position, motion, or climate.

"'I am, &c.,

"'John Barrow.

"'Admiralty, Jan. 10, 1835.'"

This was the result of the stir I caused in 1818 and 1821.

After the attention of the chronometer makers above alluded to, and many other very eminent chronometer makers for the previous century, had been directed to the production of an instrument to keep time in all climates, not one had been produced that would *preserve* a *uniformity* of rate under the following *moderate* changes of temperature —namely, 40°, 50°, 60° of Fahrenheit; they would be losing at 40°, gaining at 50°, and losing at 60°; and at 30°, 60°, and 90°, *many* seconds per day wrong.

This has been officially proved, and admits of no contradiction, and, as is but too well known, has been the source of the most disastrous and fatal results.

For confirmation of which statement, that chronometers of the first-rate manufacture, by the best makers, with Compensation-balance on the old principle of Arnold and Earnshaw, do gain at the middle temperature, and lose at each side thereof, and at the extremes, I beg to refer to the reports of the Astronomer Royal, published in the *Nautical Magazine* for October, 1845, p. 523, and also to the following extract by the editor of the *Nautical Magazine* of the same date:—

"To overcome this defect is the object to which all attempts at improvement are now directed."

In 1824 I produced several specimens of weights for Compensation-balances containing mercury, some in iron, and some in steel vessels, and some in ordinary glass thermometer tubes, each of which was condemned by the Chief Commissioner of the Board of Longitude, Dr. W. H. Wollaston, as of an unsafe construction, and, therefore, decidedly bad. But the principle of a double-action balance, he admired, and said, "that I had got hold of the 'right thread,' and believed that I should simplify it."

Berthoud states that one of the glass thermometers in Le Roy's balance was broken through a blow which the chronometer received during its trial on board the *Flora*. When I showed him an iron vessel containing mercury for the weight of the Compensation-balance, he asked me how I was to know if the mercury in either of the tubes became separated, as frequently is the case in the ordinary thermometer, which he said would not only cause it to cease to act for what it was required, but would throw the balance out of weight. With a glass bulb a defect of the kind could be seen, but glass he did not consider safe, as the circumstance of removing a chronometer from one place to another might occasion it to snap, through placing the chronometer on a table rather sharply. This conversation led to a very important discovery. He inquired if there was anything particular about two chronometers that were alongside of my regulator at the time. I told him no, only that the performance of them was so bad and extraordinary, that I knew not what to do with them, the pocket one in particular. His next question was, do both arms of the balances act equally under different degrees of temperature? I said I could not tell, as I had not put them to the test. He then said, "Why not? it would not take long to do." I very quickly took both chronometers to pieces, and the springs from off the balances, and after cleaning out the oil from the holes, I placed the balances in the upper plates, and secured them in an upright position, and placed them in the oven. I then put the bar of each balance vertical, and set light to the lamp. In about a quarter of an hour the temperature had risen to 120°, by that time the bar had become horizontal. I then placed the bar of each vertical again, when both instantaneously resumed their horizontal position. Upon taking the lamp out, and placing a basin with some pounded ice and common salt, the thermometer soon sank down to 40°, when the balances had reversed their former horizontal position, plainly showing that one limb of each balance had acted more than the other. In the balance of the pocket chronometer it was evident that the steel at one part did not adhere firmly to the brass.

I then tried the effect of a thin-edged penknife, which separated the two metals to the extent of one-fourth of the circumference with the greatest ease, while the other part remained firm. As the other chronometer had only been left with me to be cleaned, I could not interfere with or touch the balance of that, but which I have no doubt was as unsound as the other. This shows the absolute necessity for each balance to be properly tested in the frame or poising tool under various degrees of temperature from 30° to 120° of Fahrenheit, which I very much doubt being done to many chronometers, although it ought to be done to all.

(To be continued.)

ABSTRACT OF THE REPORT OF THE DEPUTY MASTER OF THE MINT

(C. W. Freemantle, Esq.),

FOR THE YEAR 1873.

The supply of silver coin during the year has been fully maintained, owing in a great degree to the arrangement already referred to, under which "blanks" for the coinage of £1,000,000 were furnished by Messrs. Heaton and Sons during six months ending in March last. The demand has continued unabated, and the amount issued, £1,034,000, though less by £204,000 than in 1872, shows that considerable exertion on the part of the Mint has been necessary to meet the requirements of the public. Of the sum named, £578,500 was issued to the Bank of England, £154,000 to Scotch banks, £2,000 to the Bank of Ireland, £222,000 to the Colonies, and £60,500 for the treasury chests abroad, besides £17,000 in threepences delivered direct to private applicants. The total amount of the latter coin issued is very remarkable, having risen from £11,475 in 1870, £12,600 in 1871, and £19,575 in 1872, to no less than £44,725, or 3,578,000 pieces, in 1873, and shows to what sudden and extraordinary demands the Mint is at all times liable.

The average market price at which standard silver bullion has been purchased by the Mint during the year is 4*s*. $10\frac{13}{16}$*d*. per ounce, as against 5*s*. $0\frac{5}{16}$*d*. per ounce in 1872, so that, the rate at which silver coin is issued by the Mint being 5*s*. 6*d*. per ounce, the seignorage accruing to the State has been at the rate of $7\frac{3}{16}$*d*. per ounce, or nearly $12\frac{1}{4}$ per cent., as against 5*s*. $0\frac{11}{16}$*d*. per ounce, or nearly $9\frac{1}{2}$ per cent. in 1872. The causes which have led to a general depreciation of the value of silver bullion, and to a consequent increase in the profit on its coinage, are too well known to need examination in this report.

The usual return showing the sums advanced to the Master of the Mint from the Consolidated Fund by the Treasury for the purchase of bullion for coinage, and the amounts repaid by the Mint to the Exchequer, during the year, is printed in the appendix. The balance of £513,029 shown in the return as due by the Mint to the Exchequer represents the amount of silver and bronze bullion in process of conversion into coin, and of the coin in store at the Mint and as yet unissued to the public, at the close of the year. It should be observed that as, under the regulations above mentioned, silver coin is now issued direct to Colonial Governments, as well as to Scotch banks and the Bank of Ireland, a stock of coin must always be retained in the Mint sufficient to meet any demands which may arise, and that the balance therefore repayable to the Exchequer will at all times be correspondingly large.

In the month of December a circular was issued by the Master of the Mint's direction, to bankers in the United Kingdom, calling attention to the position of the silver currency in reference to the circulation of half-crowns and florins.

In the case of the Colonies, their lordships eventually decided to receive at their full nominal value certain consignments of old coin which had been sent home from Gibraltar, Malta, and Ceylon, and since the close of the year they have been in communication with the Secretary of State for the Colonies as to the measures to be taken for withdrawing the old copper coinage from all British possessions in which it may still be current.

The Colonial coinages executed by the Mint during the year have been three in number, namely, a coinage of the nominal value of £6,250 in silver fifty-cent and bronze one-cent pieces for the Government of Newfoundland, a coinage of the nominal value of £6,250 in silver pieces of twenty, ten, and five cents, for the Straits Settlements, and a coinage of the nominal value of £12,000 in pieces of the same denominations, for Hong Kong. Two coinages, which the pressure of the demand for Imperial coinage has rendered it impossible for the Mint to undertake, have been placed in other hands, namely, a silver coinage of the nominal value of £8,000, in twenty, ten, and five cent. pieces, executed by Messrs. Heaton and Sons, of Birmingham, for the Government of Hong Kong, and a copper coinage of 50 tons in one cent, half-cent, and quarter-cent pieces for the Government of the Straits Settlements, entrusted in the month of May to the Calcutta Mint. An arrangement was sanctioned by their lordships in the month of October, under which a certain portion of the latter coinage was permitted to be transferred to the Colony of Labuan, for circulation in that island, subject to conditions agreed upon by the respective Colonial Governments.

In the month of August I received their lordships' authority to execute a further coinage of nickel, of the nominal value of £500 in pence and halfpence, for the Government of Jamaica; but, after making enquiry as to the price of that metal, which had risen considerably since the issue of the last coinage

of £1,000 in November, 1871, I was under the necessity of reporting that the charge to the Colony for metal alone would exceed the nominal value of the coin, and that it would not appear desirable, therefore, that the coinage should be proceeded with. A correspondence as to the steps which could be taken to meet the increasing circulation of the island was in progress at the close of the year.

Although the amount of gold melted was much below the average, the amount of silver cast into bars was again very large, and the department was fully occupied in the treatment of the "sweep" from the gold coinage throughout the period of twelve weeks occupied by the repairs of the machinery, during which the operations of the Mint, including that of melting, were of necessity suspended.

Further experiments have been made during the year with the view of determining what is the best thickness to be adopted for silver bars. For many years all bars cast for coinage were of the uniform thickness of one inch, but in 1870, for the reasons mentioned in my report for that year, the thickness of gold bars was reduced, and, although the pressure of work in the artificers' department during 1871 and 1872 delayed the completion of the new moulds required, arrangements have been made, during the course of last year, for the production of bars for half-crowns and florins of the thickness of about three-eighths of an inch. The moulds manufactured for this purpose were in use for florins at the close of the year, and the result has been so satisfactory as to render it advisable to effect corresponding reductions in the size of the bars used in the production of the lower denominations of silver coin.

The amount of bronze melted during the year has only been 45 tons. As already stated, it became necessary in December, 1872, in consequence of the demand for silver coin, to contract for the delivery of 30 tons of "penny blanks" for the bronze coinage, the Mint being too fully occupied to undertake the operations of "rolling" and "cutting" that metal, and these blanks were in process of delivery at the close of the year 1872. Since their conversion into coin, the demand for coinage not having been so great, the Mint has been able to maintain the necessary supply of pence, halfpence, and farthings by purchasing bars of the proper dimensions and converting them into coin. The result has been that, in the case both of the "blanks" and bars purchased, no melting operation has been necessary, and the amount of bronze melted, therefore, during the year, only represents the "scissel" resulting from the "rolling" and "cutting" of the latter.

It is unnecessary for me to enter into any detail with regard to the operations of coining, which have been conducted during the year with the same care and success as heretofore. I may mention, however, that the accuracy of the manner in which the work of the Operative Department has been performed was strikingly illustrated by the fact that, on the termination of the gold coinage of £24,500,000 in June last, the aggregate weight of the pieces of which the coinage was composed was found to be within two thousandth parts of an ounce of the exact standard weight prescribed by law, while the pieces composing the coinage of £6,500,000 completed in 1871, as shown in my report for that year, were of the exact standard weight. I may also refer to the experiments made in connection with the operations of "annealing" and "blanching" silver "blanks," in which changes of some importance have been introduced, tending to a more rapid completion of the coin and to considerable saving of expense.

Great difficulty has been experienced during the year, as in the latter part of 1872, in obtaining steel of good quality for the manufacture of dies, and the result has been apparent in the largely increased consumption of dies for coins of all denominations. Before the end of the year, however, a change in the shape of some parts of the dies, recommended by Mr. Hill, of which details are given in the appendix, and an improvement in the quality of the steel supplied, had a beneficial effect in reducing by about one-half the average number of dies consumed.

The Die Department is also charged with the manufacture of medals, and it has been proposed to add to this branch of the work of the department by making arrangements under which not only the medals, but also the bars and clasps attached to them, will be prepared in the Mint, and the medals mounted and finished for delivery. This work has hitherto been performed by contract, but, as it appeared that it could be more expeditiously and satisfactorily executed by the Mint itself, it has been decided, with their lordships' approval, to terminate the existing contracts on the 31st of March, 1874, and to transfer it to the Mint from that date. These changes have been carried into effect since the close of the year.

In my report for 1871 I gave details of the waste on the gold and silver coinages which

[...]ought to a close during that year, and [...]ounts realised by the sale of "sweep." [...]e same time stated that it had been [...]torily ascertained by assay that the [...]nce between the amounts of the tenders [...]d for the purchase of the "sweep" [...]he gold coinage of £6,500,000 then [...]ted, and the sum which would have [...]alised if the "sweep" had been treated [...] Mint, was not sufficient to compensate [...] loss of time which would have been [...]d by the adoption of the latter course. [...] the year 1873, another gold coinage [...] been completed, steps have as usual [...]ken to ascertain the amount of pre-[...]netal actually lost in the operations of [...]. The mechanical arrangements for [...]atment of "sweep" are still capable of [...] improvement, but the completion of a [...]e of so large an amount as £24,500,000 [...]ed to present an exceptionally favour-[...]pportunity of confirming by experiment [...]uracy of the opinion expressed in my [...] above mentioned, namely, that the sale [...]veep" containing but a small amount [...]al was preferable to its further treat-[...]n the Mint, and special care was taken, [...] the issue of tenders for the purchase [...] "sweep," to remove by washing the [...]particles of gold, and to ascertain by [...]he amount of metal remaining in the [...]s. The result of the assays made, and [...]rice received for the "sweep" sold, [...]l that the course pursued was the most [...]ageous which could have been adopted. [...]re are few points connected with the [...]ions of coinage of greater importance [...]he maintenance of accurate standards, [...]erence to which the fineness of coin [...]e determined and the integrity of a [...]ic currency guaranteed. From the first [...]uction of a gold coinage into this [...]y in the reign of Henry III., whose [...]vere 24 carats fine, or pure gold, there [...] always been "fiducial" pieces with [...] the coin could be compared; and the [...]s which have been from time to time [...] in the fineness of the coinage have [...] been accompanied by the establish-[...] of standards intended to contain the [...]proportion of precious metal prescribed [...]. Fragments of ancient trial plates, [...]enting the various changes made, are [...]reserved in the Mint, and have been [...]ed under my directions.

(*To be continued.*)

[...]ATUM.—Greenwich Sidereal Clock, page [...]ond column, line 11 from end of letter, [...] read *leg*.

Clock and Watch Makers' Asylum.

THE Annual Festival of the above Institution was held at the City Terminus Hotel, Cannon Street, on Tuesday, November 10th.

E. J. Thompson, Esq., presided, and about 200 of the subscribers and their friends sat down to supper.

During the evening Captain Poole, of the 1st Middlesex Volunteers, who responded to "The Army, Navy, and Volunteers," called upon the subscribers to rally round the Institution, and bring others to support them.

The Chairman, in giving the toast of the evening—"The Asylum"—said that though the Institution had received a vast amount of support during the 20 years it had been established, there was still a necessity for increased exertions on the part of the Trade generally. There were 15 inmates, and 3 vacancies which would be shortly filled up. There was room on the ground to erect 18 more houses, which he sincerely hoped some of the present subscribers might live to see erected and inhabited.

Mr. S. A. Brooks congratulated the workmen present upon the success of the 1s. subscription started two years since for the purpose of building a "Workmen's Memorial House" on the ground of the Asylum. The committee had £217 in hand, and the building, he hoped, would be erected and occupied by the following summer.

WE have been requested to add to our report of the result of the competition for the prizes offered by the Turners' Company, that the Mr. Frederick Garritt who is therein mentioned as obtaining the first prize in Class A of lapidary work, is an apprentice of Mr. J. Jowers, of Garnault Place.

PRODUCTION OF SWISS WATCHES.—According to the statistics of the Swiss government, there are annually manufactured in the four watch-producing countries of the world—namely, Switzerland, France, England, and the United States—a total of two and a quarter millions of watches. Of these, Switzerland produces more than half, last year about a million and a half, equivalent in value to 88 millions of francs. France does not produce a fifth of that number; England, according to these statistics, only 200,000; and the United States half that number. The little canton of Neuchâtel yields as many watches in a twelvemonth as England and the United States combined do in three years. The annual product of the watchmaking industry of the four countries is estimated at 120,000,000 francs.

Abstract of the Principal Changes of Rates of Chronometers

NAME OF MAKER.	No.	ADDRESS OF MAKER.	CONSTRUCTION OF BALANCE.
Sewill	3084	30, Cornhill, London.	Auxiliary compensation
Kullberg . . .	2883	105, Liverpool Road, London.	Improved ordinary balance.
Sewill	3072	30, Cornhill, London.	Auxiliary compensation.
McGregor & Co. .	$\frac{x}{3510}$	45, Clyde Place, Glasgow.	Auxiliary to balance acting in extremes.
Reid & Sons . .	2408	41, Grey St., Newcastle-on-Tyne.	Auxiliary compensation.
Gowland . . .	1305	178, High Street West, Sunderland.	Auxiliary compensation.
Highly	5435	45, High Street, Sheerness.	Auxiliary acting in cold.
Chittenden . . .	793	10, Wilton Road, Hackney, London.	Balance as in former years.
Keys	363	15, Craven Street, Strand, London.	Auxiliary compensation.
Lowry	1776	66, High Street, Belfast.	A safe auxiliary compensation to balance.
Kullberg . . .	2871	105, Liverpool Road, London.	Kullberg's flat-rim balace without auxil.
Johannsen . . .	1823	149, Minories, London.	Auxiliary compensation.
Keys	364	15, Craven Street, Strand, London.	Auxiliary compensation.
Johannsen . . .	1820	149, Minories, London.	Auxiliary compensation.
Penlington&Hutton	2137	2 & 3, St. George's Cresc., Liverpool.	Auxiliary compensation.
Brotherton . .	5417	11, Spencer St., Goswell Rd., Lond.	Construction as in former years.
C. Frodsham . .	3519	84, Strand, London.	Three compensation bars balance.
C. Frodsham . .	3554	84, Strand, London.	Balance with continuous auxiliary.
James Poole & Co.	5656	33, Spencer St., Clerkenwell, Lond.	Auxiliary compensation.
Williams . . .	1762	2, Bute Docks, Cardiff.	Auxiliary compensation.
Sewill	3222	61, South Castle Street, Liverpool.	Auxiliary compensation.
Hennessy . . .	4940	5, Wind Street, Swansea.	Auxiliary compensation.
Gowland . . .	2273	178, High Street West, Sunderland.	Auxiliary compensation.
Whiffin. . . .	352	10, Cloudesley Sq., Islington, Lond.	Auxiliary compensation.
Penlington . .	2136	2 & 3, St. George's Cresc., Liverpool.	Auxiliary compensation.
Fletcher . . .	3369	148, Leadenhall Street, London.	Auxiliary compensation.
Hennessy . . .	4868	5, Wind Street, Swansea.	Auxiliary compensation.
Davison . . .	4895	6, Side, Newcastle-on-Tyne.	Auxiliary compensation.
McGregor & Co. .	$\frac{F}{3073}$	45, Clyde Place, Glasgow.	Auxiliary compensation.
Lowry	1778	66, High Street, Belfast.	A safe auxiliary compensation to balance.
Shepherd & Son .	1810	53, Leadenhall Street, London.	Auxiliary to balance.
Reid & Sons . .	2402	41, Grey St., Newcastle-on-Tyne.	Auxiliary compensation.
Shepherd & Son .	1789	53, Leadenhall Street, London.	Auxiliary to balance.
Whiffin	361	10, Cloudesley Sq., Islington, Lond.	Auxiliary compensation.
Sewill	3247	61, South Castle Street, Liverpool.	Auxiliary compensation.
Muirhead & Sons	$\frac{J}{5813}$	90, Buchanan Street, Glasgow.	Double auxiliary.
Davison . . .	4963	6, Side, Newcastle-on-Tyne.	Auxiliary compensation.
James Poole & Co.	5655	33, Spencer St., Clerkenwell, Lond.	Auxiliary compensation.
Russell & Son .	2784	30 & 32, Slater Street, Liverpool.	Auxiliary compensation.
Isaac	1129	147, Liverpool Road, London.	Balance as in former years; no auxiliary.

The sign + indicates that the rate is gaining.

During four weeks from the 7th March, and during four weeks from the 13th June, the Chronometers were placed in the chamber of a stove heated by jets of gas. The gas flames are exterior to the chamber, into which none of the injurious products of combustion can enter.

The ratings commenced January 10th, and ended August 8th, so that the duration of the trial was thirty weeks.

The Chronometers are placed in order of merit, their respective positions being determined by consideration of the irregularities of rate exhibited in the Table above.

on Trial at the Royal Observatory, Greenwich, 1874.

Least Veekly Sum.	In what Temperature (degrees Fahrenheit).	Greatest Weekly Sum.	In what Temperature (degrees Fahrenheit).	Difference between the greatest and least.	Greatest Difference between one week and the next.	In what Temperature (degrees Fahrenheit).
s		s		s	s	
2·5	{57 to 84 / 62 to 90}	+ 12·4	63 to 70	9·9	5·7	51 to 57
3·5	47 to 53	+ 6·0	70 to 90	9·5	6·1	63 to 78
6·1	41 to 50	+ 5·0	63 to 78	11·1	6·2	53 to 66
3·7	36 to 49	+ 7·5	51 to 57	11·2	6·3	36 to 49
7·5	68 to 85	+ 4·0	64 to 71	11·5	6·6	36 to 49
8·0	82 to 96	+ 5·0	51 to 57	13·0	6·0	65 to 87
6·0	36 to 49	+ 7·0	{51 to 57 / 51 to 59}	13·0	6·0	51 to 57
7·0	68 to 85	+ 5·6	36 to 49	12·6	6·5	51 to 57
2·1	58 to 66	+ 10·5	70 to 90	12·6	7·0	57 to 84
0·0	46 to 51	+ 11·5	70 to 90	11·5	7·7	57 to 84
3·0	45 to 51	+ 17·2	67 to 76	14·2	6·5	82 to 96
8·9	36 to 49	+ 3·5	70 to 90	12·4	7·7	57 to 84
2·5	45 to 53	+ 17·5	{70 to 90 / 82 to 96}	15·0	6·5	57 to 84
12·0	50 to 56	+ 1·0	62 to 90	13·0	8·0	51 to 57
11·0	45 to 51	+ 23·4	58 to 66	12·4	8·6	67 to 76
6·6	82 to 96	+ 7·5	51 to 59	14·1	7·9	86 to 96
3·5	46 to 51	+ 22·6	82 to 96	19·1	5·5	70 to 90
3·8	50 to 56	+ 16·3	67 to 76	12·5	8·9	50 to 56
3·4	45 to 53	+ 13·0	82 to 96	16·4	8·3	57 to 84
17·5	36 to 49	— 4·7	57 to 84	12·8	11·1	57 to 84
10·0	82 to 96	+ 29·9	58 to 66	19·9	8·2	82 to 96
6·7	45 to 51	+ 16·7	64 to 71	23·4	6·8	82 to 96
11·5	{62 to 90 / 68 to 85}	+ 6·9	58 to 66	18·4	9·5	57 to 84
0·5	70 to 76	+ 16·9	36 to 49	16·4	11·2	50 to 56
0·9	45 to 51	+ 26·5	70 to 90	25·6	7·1	57 to 84
5·7	62 to 90	+ 23·6	53 to 62	17·9	11·0	50 to 56
10·7	65 to 87	+ 8·2	44 to 50	18·9	11·7	50 to 56
15·7	57 to 84	+ 3·0	82 to 96	18·7	11·9	82 to 96
1·7	57 to 84	+ 22·6	82 to 96	24·3	11·1	50 to 56
1·4	46 to 51	+ 25·0	{62 to 75 / 64 to 71}	23·6	11·9	58 to 66
11·5	82 to 96	+ 11·4	58 to 66	22·9	13·2	82 to 96
29·3	36 to 49	— 3·0	51 to 59	26·3	12·1	57 to 84
22·7	46 to 51	— 3·0	57 to 84	19·7	16·8	57 to 84
6·2	45 to 51	+ 30·7	51 to 59	36·9	8·5	50 to 56
9·5	70 to 76	+ 12·1	36 to 49	21·6	20·5	82 to 96
10·5	36 to 49	+ 28·1	70 to 90	38·6	13·5	57 to 84
4·8	36 to 49	+ 27·6	86 to 96	32·4	19·5	57 to 84
9·7	46 to 51	+ 29·6	67 to 76	39·3	16·3	57 to 84
33·4	45 to 51	+ 21·0	67 to 76	54·4	24·1	57 to 84
2·0	57 to 84	+ 9·0	50 to 56	7·0	3·5	65 to 87

The Chronometer Isaac, 1129, was purchased by the Admiralty during the course of the trial, to replace a Navy ronometer sold to another department. On account of the shorter trial, its rates are not comparable with those of the ıer Chronometers; it is, in consequence, placed in a separate division. Another Chronometer, having exhibited such egularities in its rates as to indicate some derangement of its mechanism, was withdrawn by the maker, by permission.

All the Chronometers were two days. The lowest temperature in which they were tried was 36° Fahrenheit, the ghest 96° Fahrenheit.

A SIXTY-SIX CARAT DIAMOND.

We have been favoured by Professor Tennant with a view of a very choice diamond which he possesses. It has a delicate yellow tinge, and weighs 66 carats, and has been valued at £20,000, although, applying the rule given by Jeffries and other authorities for ascertaining the value of cut diamonds (quoted by Professor Tennant in his much-esteemed lecture on Mineralogy, with especial reference to watch jewelling, delivered before the members of the Horological Institute, and published in vol. ii. of the *Horological Journal*), viz., multiply the square of the weight in carats by 8 and call it pounds sterling—its value would be 66 × 66 × 8 = £34,848. Fig. 1 represents the crystal weighing 112 carats,

Fig. 1.

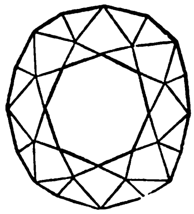


Fig. 2. Front view.

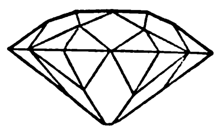


Fig. 3. Side view.

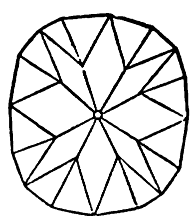


Fig. 4. Back view.

which, Professor Tennant recently remarked in one of his lectures on Mineralogy at King's College, was brought to him by one of his former students. Figs. 2, 3, and 4 show the beautiful brilliant in its present form, the cutting having been executed in London, where, it is satisfactory to know, the art is being resuscitated. English diamond cutters were the most celebrated in the world 150 years ago; but, as these died off, the trade fell into the hands of Jews, who, being at the time subject to great injustice, socially and otherwise, both in England and elsewhere, migrated in large numbers, including the diamond cutters, to Amsterdam, the only city which gave them comparative freedom; and thus the diamond cutting became there established. That the art is again likely to flourish as an English industry, is due to the enterprise of Mr. W. Ford, of Red Lion Street, who has fifteen diamond cutters and polishers, all Englishmen, at present in his employ. The cutting of the gem, here depicted, affords a fair sample of the excellent work done in England. Being anxious to encourage the cutting of diamonds and other precious stones, the Turners' Company have this year offered prizes for lapidary work. In the King's College lecture, to which we have already referred, Professor Tennant remarked, that the chief art of the diamond cutter lies in the breaking of the stones so as to remove flaws when they exist, and to get the largest possible gem out of a given crystal. As an example of the commercial application of scientific knowledge, he instanced the case of Dr. Wollaston's purchase from Messrs. Rundall and Bridge, the Crown jewellers, of a faulty diamond for £6,000, and then, after removing the flaw and making a jewel for a ring and a set of shirt-studs out of the piece removed, re-selling the then perfect stone for the sum of £7,000.

Turning from diamonds to sapphires, Professor Tennant mentioned that a gentleman had, on the previous day, brought him the specimen of corundum, which he then exhibited; he had never seen anything to equal it, yet he was told it came from a vein extending over a space of country 300 miles long. As a practical application of a little elementary knowledge, it was mentioned that the Professor, in taking leave of a pupil, who was about to start for the Cape, put into his hands a piece of corundum, remarking, "If you find any stone that scratches that, it must be a diamond." It is interesting to state the use made of this knowledge: the gentleman was present at Du Toit's Pan, in the diamond fields of South Africa, and saw a bucketful of mud taken up, from which a pebble was produced; on asking leave to examine it, it was found to scratch

the corundum, and £1,000 was immediately offered for it and accepted; within a week it was sold for £6,000. Both oriental topaz, ruby, and sapphire were shown in the stone. He remarked that the finest sapphire was in the possession of Lady Burdett-Coutts, and had formerly been one of the Crown jewels of France, but was sold in London after one of the revolutions of that country; it was this circumstance that made the late Emperor so desirous to acquire that particular stone for France. Comparing corundum with quartz, to which it bears some resemblance, the Professor explained that they could readily be distinguished from each other; the hardness of the quartz is 7, whilst that of corundum is 9; and if, again, a crystal of each were broken, it would be found, whilst the corundum would break into rhombs on each alternate angle, the quartz would break with a curved fracture. The best way however of distinguishing them was to take their specific gravity, that of corundum being 3·9, whilst that of quartz was but 2·6.

Letters to the Editor.

All Letters to be addressed to the Editor, at the Institute, 35, Northampton Square, E.C.

To the Editor of THE HOROLOGICAL JOURNAL.

ISOCHRONISM.

SIR,—In reply to "Unique"—How is it possible for a balanced wheel to revolve backwards and forwards round a fixed axis so that a spring may be applied to it for mechanical purposes to show anything like an isochronal principle—the balance may be fixed, but the axis on which it is fixed must revolve. Secondly, the spring has no power of whirling (quite a new word, this whirling, in Horology) a balanced wheel, but the spring itself is a governor of the wheel so balanced (or whirled) by the motive force of the watch or machine to which the balance is applied, and the spring is to the balance that force that gravity is to the pendulum. The spring in itself has not the power of producing motion, and would always remain in its quiescent state unless disturbed. Then when motion is given to the balance, the force of the spring, its restituting force, is exerted, be the applied force much or little, but the greater the force applied, so is the spring's effort greater or less to return. I will agree with "Unique," that the subject of isochronism is not restricted to watch making, and that the fact does exist and has existed in all bodies in equilibrium ever since the universe began; but the fact was not discovered until the time of Galileo, and it is said to have been observed by him when a child, by the swinging of a lamp from the roof of a cathedral at Pisa; and this observation in a child became in the mind of a man a principle of philosophy, on which some of the greatest discoveries of science have been founded. If friction and atmospheric resistance are to be left out of the question, a balance provided with a spring that possesses perfect elasticity, and uninfluenced either by friction or the resistance of the air, would go on vibrating backwards and forwards without cessation. But three retarding influences really act upon it—want of perfect elasticity of the spring, so that each reacting force is somewhat less than the force which acted upon it; friction of the pivots, and resistance of the air. Hence, in order to keep up these vibrations, it is necessary that a slight additional impulse should be continually given to the balance as to the pendulum.

In reply to "F. E.," I trust there are not many readers of the *Journal* that do not understand the meaning of the word equilibrium, but for the especial information of "F. E.," I beg leave to state that in any length of spring applied to a balance, an isochronal point may be obtained, and that after this point has been obtained, the timing must be done by the perfect poisation of balance; or in other words, the weight of balance must be so regulated to suit the spring, and not the spring taken up or let out to suit the balance.

I am, Sir, &c.,
ONUS PROBANDI.

SIR,—"Onus Probandi," in the October number of the *Journal*, remarks that the vibrations of a musical (pianoforte) string are isochronous. This I believe to be quite true, for if otherwise I think I should have noticed it, having had considerable experience in pianoforte and harmonium tuning for about fifteen years; but I cannot see much family likeness between the vibrations of a musical string, stretched between two fixed points, and the isochronous vibrations of a balance-spring, which is free, for the balance-spring in bending must be compressed on one side and stretched on the other; but in a musical string the material is stretched even when at rest, and no compression can possibly take place in any part of it, whatever may be the extent of its vibrations; and

I think the elastic properties which are called into action on the string must be in some way different from those in the balance-spring, because a silk or catgut string is quite as isochronous in its vibrations as the best-tempered steel wire one, such as are used in pianofortes.

But the vibrations of the reeds used in harmoniums, accordions, concertinas, &c., which are simply flat straight springs, fixed at one end and free at the other, may be considered more like those of the balance-spring, and it is most annoyingly evident to any good tuner that the vibrations of *all* the reeds in a harmonium are not by any means isochronous, for the bass notes flatten with an increased extent of vibration, while the high treble ones sharpen under the same circumstances, and *vice versa;* but I have repeatedly proved that it is quite possible to make their vibrations either isochronous or the larger vibrations faster or slower, and *vice versa*, by varying the proportionate thickness of different parts of the reeds. I once tuned, for the sake of experiment, about 50 reeds, but only extending over two octaves, in which the loudest sound they would produce, and the softest that could be heard, were perfectly in tune one with the other, even taking the lowest and highest note together; which simply means that whatever the proportionate rates of vibrations of any two reeds might have been (and which it is unnecessary to state here), that exact proportion was maintained through every variation in the *extent* of the vibrations.

Thinking these few facts might possibly be interesting to some readers of the *Journal* is my excuse for troubling you with this rather long letter.

Yours, &c.,

Sundridge. J. VIRGO.

DRUM TIMEPIECES.

SIR,—These timepieces have taken up a great deal of my time, labour, and thought; still I cannot get them to give satisfaction. I have a new one now in hand; the end-shakes are good, and depths, &c.—in fact, it is everything that can be desired, as far as freedom goes; still, it stops apparently for want of power, although it has a strong main-spring, and runs down smoothly. They all seem to stop on the round face of the pallets (the pallets embrace one tooth). If any reader would kindly oblige by advising me how to proceed to cure the evil I should be exceedingly obliged.

Yours,

PLYMOUTH.

CLOSING SECONDS'-HANDS.

SIR,—In the November number of the *Journal* I saw a description of tool for closing the sockets of hour and minute hands.

I here send you the description of a small tool I have found very useful for closing the sockets of seconds-hands, and which makes a far neater job than the way usually adopted —*i. e.*, nipping the socket with the pliers.

A piece of nicely hardened and tempered steel, about 1 in. by ¼ in. by 5 douziemes thick, with 6 holes, nicely tempered and polished, graduated to take the largest and smallest socket.

To use the tool, put the socket in whichever hole it will partly enter, and give a slight tap with a hammer, and the job is done in a neat and workman-like manner.

Yours, &c.,

W. E. PERRETT,

Weston-super-Mare.

To Correspondents.

Upon an old English clock we find the name "A. Fromantell, London." Can you enlighten us as to the date this person existed?—REID AND SONS.

ERNEST R.—*Mechanism to wind the watch by the motion of the wearer's body in walking is not new, although your arrangement may be. We cannot recommend a patent agent.*

CIVIS.—*The Clockmakers' Company was incorporated by Royal Charter in* 1631. *The company has no hall, and has, we believe, removed its library to the Guildhall.*

S. L.—*The rapid cutting of cylinders you mention may be caused as you suggest by their softness, but, probably, by the oil being drawn away from the acting part by capillary attraction, as described by Mr. Schoof, in the Journal for December,* 1873. *The grinding noise in cylinder watches, continuing throughout the whole vibration, is probably caused by rough jewel-holes or rough pivots.*

I have a watch of the following description, and should like to know if it is a curiosity, or whether there are more about like it:—A small silver pair-case verge; the minute-hand only makes one revolution in two hours, the hour hand goes as usual; each half of the dial is marked into sixty minutes, ten between each figure, the fusee carries two-and-a-half coils of chain, and the train has one extra wheel, and the entire escapement is left-handed. It is well made, and has the name of "Wm. Ericks, London, No. 604."—R. E. C.

British Horological Institute.

journed Meeting for discussing Mr. W. B. CRISP'S Essay on the Compensation Balance, held on Tuesday, December 8th, 1874.]

Mr. JOHN JONES, F.R.G.S., Vice-President, presiding.

: CHAIRMAN having briefly recapitulated points which engaged consideration dur- the first evening devoted to the discus- , a report of which appeared in the ember number of the Journal, expressed pleasure he felt in the presence of Mr. lberg, who had, in a letter read the first ing of the discussion, questioned Mr. p's statement, that the cause of the r in the ordinary compensation balance due to the curvature of the path de- bed by the weights.

r. JAMES U. POOLE felt that Mr. Crisp done good service to the trade by the ication of his essay. For his own part elt that the Horological Institute was g a great work, and he had always ed forward with interest for the appear- of the journal, the matter in which much improved of late, and could not to benefit many practical men who were stomed to do many things for which could not give a reason, and who found there were proper ways of expressing, giving rules for, the results they arrived With regard to the chronometer as a plete instrument, it often happened that ains relied very much on their own ob- tions for testing its accuracy, and, con- ently, were not disposed to pay a suffi- price for a finely-finished chronometer. e Greenwich trial was the means of ring a certain number of first-class in- nents to be placed at the service of the rnment, but it did not always follow makers could make a number of equal llence to those which might head the list. ith regard to the question of auxiliaries, uld not help thinking that that applied is late uncle—Mr. John Poole—and ibed by Mr. Crisp, was as simple and ble as any in existence, and, without t, it had been very extensively used by rade, not having been patented.

e last time the auxiliary appeared by in the Greenwich trial it took a very position, but he might mention that he been told by the owner that the chrono- r had just returned from a two years' voyage, during which time its rate had been absolutely perfect. In conclusion, he would observe that, taking into consideration that watch balances were liable to all the unfavourable influences which affected the large ones, and furthermore that they had no auxiliaries, it was a matter of surprise that watches and pocket chronometers performed as well as they did, and it often happened that accuracy could only be obtained by a series of troublesome experiments, extending over a period of several months.

It was, no doubt, a great advantage to have a continual standard of excellence kept before the trade, and to endeavour to take advantage of every practicable suggestion, which was the real object of the Institute.

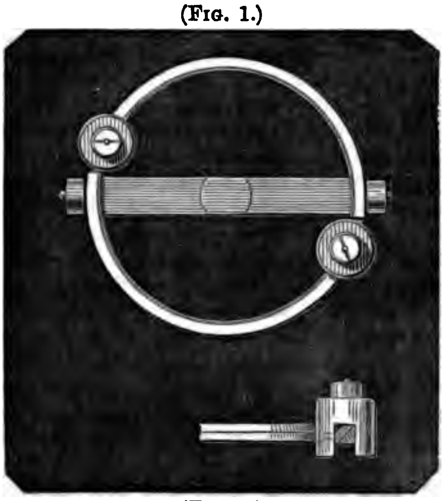
Mr. MERCER said it was soon discovered that chronometers fitted with Earnshaw's balance gained several seconds in medium temperature, and to cure this evil Molyneux's spring and laminated auxiliaries were introduced. But Earnshaw's contemporary, Arnold, had also invented a compensation balance, consisting of two weights, screwed on long pillars at the ends of a laminated arm, representing three sides of a square. This arm would be at its greatest diameter when straight; and if so, at say 60°, and heat were applied, both arm and uprights would go in to the centre upwards. And in cold, all above the arm going outwards downwards; the arm itself, as soon as past the horizontal line, going in. The action of this balance being mostly in the long arms and weights that multiplied the action of the bar, would have the same intermediate error as Earnshaw's. Then Mr. Hartnup invented the gridiron-shaped lamina, connected to a sloped rim, upon which the weights were placed. Instead of the lamina being only a length equal to half the diameter of the balance, as in Arnold's case, Mr. Hartnup obtained a lamina equal to a diameter and a quarter of the balance, and the weights would have been lower than Arnold's had he used uprights; but balances of this kind required the greatest care in adjusting, and unless made too stout to be

active, were very fragile. Mr. Kullberg simplified the matter by abandoning the gridiron and laminating the rim. The whole secret of Mr. Kullberg's balance was contained in the great length of the lamina, it being equal to two diameters, giving a greater lifting action in the balance and requiring lower uprights. The lower the weights were placed on the rim in balances of this kind the better they would act.

Mr. KULLBERG quite agreed with Mr. Mercer that the weights on his balance should be placed as low as possible, and gave a description of what he called a "low rim" balance of his construction, exhibited in the Paris Exhibition of 1867, which will be best understood by a reference to the annexed diagram, which we are enabled to give by the courtesy of Mr. Kullberg.

Fig. 1 shows Kullberg's low rim balance in plan, and Fig. 2 in elevation. The

(FIG. 1.)



(FIG. 2.)

central bar is compensated, the brass being above, and the steel underneath. It is of larger diameter than the ordinary balance, in order to get the utmost length of central lamina. The rim is half the width of the ordinary rim, and nearly double the thickness, for the sake of getting the compensation weights at the end of the rim—close to the bar. As in the flat rim balance, the action produced by the bending of the central lamina is thus considerably multiplied. In order to further assist what may be called the inclined action, caused by the central lamina, the steel of the rim is turned so as to run nearly diagonally from the outer top corner to the inner lower corner; the upper inner corner being taken off, leaving a surface nearly parallel with the outer surface of the steel, the two metals composing the rim being afterwards turned upright and square. The section of the rim is shown to an enlarged scale by Fig. 3. This rim will bend upwards

(FIG. 3.)

at the same time that it bends inwards, and Mr. Kullberg said that, owing to so great a length of the rim running, so to say, by the side of the centre bar, an action so ample was obtained that the chronometer in question actually *gained* half a second in each extreme between 30° and 100°, which almost made him believe that a solid steel rim of the same section (instead of one composed of compensation lamina) would act enough to reduce the error in extremes to almost *nil*. He also mentioned an auxiliary, or, as he called it, an improved ordinary balance, of which we are also enabled to give a drawing. Fig. 4, being a plan, Fig. 5 an elevation of the balance,

(FIG. 4.)

(FIG. 5.)

which, as will be seen, is of the ordinary kind, but crossed out so as to allow the part of the rim that generally carries the extra screws to check against itself. The rim is cut open nearer the middle than the ordinary

balance, so that a long piece of lamina is obtained which carries screws for correcting the error in extremes. The checking action is thus accomplished. The above-mentioned part of the rim is divided into two parts by a slit along the rim; the upper part has a knee at the end, filed out of the bottom of the balance, which touches a small screw tapped into the extremity of the lower and much stouter portion of the lamina, thereby causing a gentle check when the temperature falls below 65° or 60°. Mr. Kullberg said the action of the screws was very considerable, owing to the great length of the lamina from its fixture at the bar, and that therefore the moment of contact was very easily discerned in a range of a few degrees of temperature, and the only additional pains necessary in the construction of the balance was the two small steel screws and the extra trouble in filing out the ordinary rim. Considering these advantages, and bearing in mind that it attained the great desideratum of leaving the main compensation undisturbed, he was led to the conclusion that it was the simplest and best auxiliary at present contrived. He thought it rather remarkable that the two auxiliaries mentioned in Mr. Crisp's essay should both have been of the kind that acted on the main compensation, which had for a considerable length of time been felt to be objectionable by men of experience. He also thought it so singular that Mr. Crisp had not more fully explained the causes of irregularity or want of sufficient action in balances without auxiliaries or checks, because it was for want of knowledge upon such points that inventions had so often failed; instead of which, Mr. Crisp condemned attempts without giving the least guide. He felt satisfaction that the essay had been supplemented by discussion, as its principal aim appeared to be to show the value of the old faulty balance, and to pronounce all other balances or auxiliaries unreliable.

The Chairman said that he had some years ago, and on more than one occasion, tried the experiment of placing half a dozen steel balances for 14-size watches in ice, and afterwards subjecting them to a temperature of 85°, the result in each case being a loss of five to six minutes in the higher temperature, which agreed with the observations of the Astronomer-Royal, showing that the variation of a chronometer, with an uncompensated balance, would be uniformly about one minute for every 10° change of temperature, from which it would seem to follow that the compensation weights, to counteract such variation, should approach the centre of the balance, or recede from it in the same ratio as the change of temperature, yet agreeable to the law of the square of the diameter of the balance.

Mr. Glasgow thought the Chairman's conclusion as to the proportion the movement of the weights to or from the centre of the balance should bear to the change of temperature was hardly clear. The Astronomer Royal's experiment demonstrated two facts: 1st, that the total temperature error, with an uncompensated balance, amounted to about six minutes in 24 hours for a change of 60° in temperature; secondly, throughout that range of 60°, the error varied in the same proportion as the temperature, being constant at about six seconds for a change of one degree. If then change of temperature caused an error varying arithmetically, it clearly followed that the compensating power should vary arithmetically also. But if the weights approached the centre of the balance, or receded from it in the same proportion as the changes of temperature—which in the ordinary compensation balance they practically did—their action would be wrong, for a very simple mechanical reason that, singularly enough, seemed to be entirely ignored. The controlling power of a balance varied as the square of its diameter, consequently, while the diameter of a balance varied arithmetically, or in the same ratio as the error occurred, its controlling power would vary geometrically. The fact of what was erroneously called the middle temperature error being inseparable from the principle upon which the ordinary compensation balance acted, being so forcibly in his mind, caused him to suggest, on a former occasion, the advisability of acting upon the spring for correction of the greater portion of the total temperature error. If, however, the ordinary compensation balance were retained, the effect of its error might very readily be lessened by placing the timing nuts, which were in a line with the straight steel arm, inside the rim instead of outside, the effect of the change being that with an increase of temperature they would slightly decrease the effective diameter of the balance, instead of increasing it as they did at present.

Mr. Crisp, in reply, said he considered Mr. Kullberg's remarks as to the weights not fitting the balance, too vague for the poorest mechanic to reply to. If he had read a little further on in the essay, he would have seen it stated that the balance-maker's attention was required in nicely fitting the slot of the weight to the balance, so that there should be no bending or twisting of the laminæ or

rim of balance: he did not describe his balance more fully, as he considered the Hartnup balance, which was so fully described in the essay, and Mr. Kullberg's balance, acted precisely in the same manner, and it was a mistake for Mr. Kullberg to suppose that he did not understand the action of it; but he could not describe the method of making it, as he had said before, on account of not being able to procure one. His impression was, that it acted in a geometrical ratio, as an inner and outer circle, and that the disc being flat, lengthened, as it were, the arm of the balance, and gave it a more rapid curve even than the Hartnup balance. And as to the failure of auxiliary compensations, he considered it to arise from defective handicraft alone. Take, for instance, the late Mr. Poole; he had been highly successful with his auxiliary compensation pieces, which he managed with a peculiar skill that he could not impart to any of his successors. And Mr. Mercer, again, had been very successful with auxiliary compensations during the last Greenwich trials, and Mr. Crisp was particularly struck with the closeness of the performance of the four chronometers on the Greenwich trials of this year, which, he understood from Mr. Mercer, were of his timing and adjusting entirely.

In reply to Mr. Glasgow, his motive for arriving at the conclusion he did was, seeing that in the uncut balance, or plain uncompensated balance, the error was so regular, from the table published by the Astronomer-Royal, that the form of balance remained unchanged—or did not depart from a true circle during its trials from 30° to 90°—and by its performance, arrived at the conclusion that the ordinary compensation balance compensated for the whole of that error within $\frac{1}{15}$th of a second for every degree of temperature, or 6 seconds for the same range of temperature that showed the error with the plain brass balance to be 6 min. 32 sec.

In reply to Mr. Strachan, the note at the end of his essay might be taken in two ways, in fact, it ought not to have been inserted at all,* as it was his full intention to have described the uses of a chronometer at sea, and the methods of taking the time, or observation, from the sun, but he concluded that the mariner was sure of his longitude from his last observation, and had nothing then but his own experience to guide him, until he had other opportunities afforded him of determining his longitude. A full description he might give on a future occasion. He was not aware he had anything more to reply to, but if any other gentleman had more questions to ask, he would reply to the best of his humble ability.

* The foot-note to which Mr. Crisp refers was inserted by his express desire.—Ed. H. J.

The Chairman said he thought they had every reason to be satisfied with the result of the discussion. They had heard the opinions of some of the most eminent men in the trade on the subject of Compensation, and he doubted not the reports of that discussion in their journal would be attentively read by horologists not only in England, but in America, and he might even say all over the world, and a consideration of some of the points raised would probably lead to some practical result.

On the motion of Mr. Glasgow, a vote of thanks was enthusiastically accorded to the Chairman for presiding.

Clock and Watchmakers' Asylum.

On Thursday, the 17th December, was held, at the Crown Tavern, Clerkenwell Green, the second annual meeting of the subscribers to the Workmen's Memorial House Fund, presided over by Mr. S. A. Brooks, to whom, we believe, the idea of endeavouring to build additional houses in connection with the Asylum by means of one shilling subscriptions is due. About two years ago a small committee was formed to carry out the idea, but no one who has the least idea of the difficulty of raising two or three hundred pounds by means of shilling subscriptions among workmen in one particular trade will be surprised to hear that some hitch occurred, and for a time the project seemed to fail, and no doubt would have dropped entirely but for the energy of Mr. Brooks, who seems determined to prove the practicability of his idea. We learned with satisfaction that the committee have now more than £200 in hand, and only await favourable weather to begin building. We trust that those who have not already subscribed will at once do so, if only to show their appreciation of the perseverance which has accomplished so much. The committee include Mr. Brooks, Mr. Baxter, Mr. Crickmore, Mr. Collier, and Mr. Spring.

[Referring to the report of the festival given in the Journal last month, for which we were indebted to the secretary of the asylum, Mr. James U. Poole desires us to say that he is captain, not of the 1st Middlesex, but the 39th Finsbury Rifle Corps, and that he appealed to the trade to support his, the No. 1 Company, which he desires should be known as the Clerkenwell Company, and did not specially refer to the claims of the asylum.]

AN ESSAY ON COMPENSATION,

FOR CORRECTING THE ERRORS IN TIME-KEEPERS ARISING FROM CHANGE OF TEMPERATURE.

BY JOHN GOTTLIEB ULRICH.

(*Continued from page* 56.)

About the beginning of 1825 I invented a tubular Gridiron-balance which was equally as sensitive as mercury; and, if correctly made, would answer the purpose tolerably well from 25° to 90° Fahrenheit, but not higher; it was, therefore, abandoned for the present. I was then equally unsuccessful with my Gridiron-pendulum, but have recently surmounted the difficulties I had to then contend with.

A drawing and description of that Gridiron-balance is to be seen in my patent of 1828.

At the time when the annual trials for the prize ceased in 1834, and a promise of reward for attempts at improvement was offered, I made application to the Board of Admiralty, and in February, 1835, received the sum of fifty pounds from their lordships, upon the recommendation of their Scientific Committee (among whom was Dr. Olinthus Gregory, of the Royal Academy, Woolwich, and Admiral Sir Francis Beaufort), for the purpose of making further improvements.

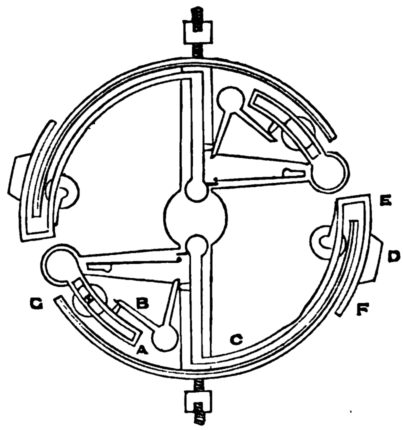
In 1840 application was made by several persons to the Admiralty on the subject of Compensation, and in 1842 a pamphlet was published by order of the Admiralty, containing a description of a variety of contrivances designed to effect the same object as mine. There is now scarcely a chronometer sent to Greenwich on trial for purchase but what has got some contrivance of my *double-action* balance, or an additional and auxiliary Compensation, under some modification of it.

I have previously shown that to obtain a Compensation balance that should act properly at all temperatures to which it is likely to be exposed, it was requisite to make a balance whose weights should be gradually shifted forward for an increase of temperature, and backward for a decrease of temperature, thereby causing a greater quantity of weight to approach the centre of the balance for any given increase of temperature than what should *recede* for a corresponding decrease of temperature. *This is the grand secret.*

The ccompanying drawings will show some of the various stages by which that object has been accomplished; from the complicated form in which it was at first made, up to the present time, in its most simple form.

Fig. 1 represents a continuous double-action Compensation balance, with a combination of levers, that are acted upon through any change of temperature, by the useless portion of the laminæ, acting first upon the

(Fig. 1.)



friction roller in the lever A, which by acting on the lever B, moves the lever C, which carries the Compensation-weight D, which can be shifted towards E or F at pleasure, to adjust the amount of general or primary Compensation.

The amount of action that it is desirable to make the Compensation-weights traverse the periphery of the laminæ, is by shifting the friction roller on the lever A, bringing it towards G if it does not do enough, and toward H if it does too much; that is, if it should lose in the middle temperature, and gain at the extremes, or each side of the central temperature.

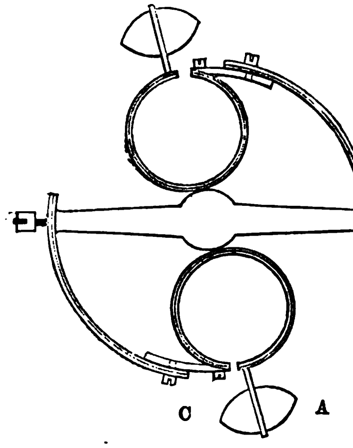
Fig. 2 represents a continuous double-action balance, that will stand the test for change of temperature from Zero to 120° of Fahrenheit.

Where there is sufficient height (as there is in the box chronometer), the small compensation circles had better be placed to a small stud outside of the main laminæ on the periphery of the balance, and the brass

of them placed *outside* of the steel. They are easier to make, and the brass can be made *much* harder. This balance is better than that represented by Fig. 1, inasmuch as most of the weights is concentrated in or near the laminæ, and as far from the centre of the balance as possible.

In the small circles of the drawing, Fig. 2, the *steel* must be *outside*. The weights have *two* actions; upon an increase of temperature

(FIG. 2.)



they not only move towards the centre, but towards the letter A, and *vice versa* for cold, towards the letter C.

Stops have been applied to retard the outward progress of the weights when the temperature sank down to about 50°; but then, in the event of a continuation of cold, perhaps to 25° or 20° of Fahrenheit, the probability is, that the balance will receive such a strain that will tend to bend the laminæ, and so *far* too as to *set* it, that *at* 90° it may not have resumed its former position, and become *many* seconds per day too fast.

Numerous as are the modifications of my original construction of continuous double-action Compensation balances, and various as are the contrivances of auxiliaries that have been made to effect the same object, there is more going forward that I think will supersede anything of the kind that has yet been done, both for simplicity as well as efficiency, and I verily believe that in a few months I shall succeed in producing a Compensation to act upon the spring (whether at the collet or the stud, or at both, I am not yet certain). If so, a simple plain balance with two small mean-time screws (or nuts) will suffice.

I most humbly submit that this is a subject worthy of the attention of the scientific horologer.

I have made many kind of curbs, but have not produced one to my satisfaction. I enclose a few sketches of some of them.

What metals (and the proportions of them) are best for Compensations is a subject for further discussion, and is now under investigation, for which experiments are being made.

In the manufacture of Compensation balances, too much care cannot be bestowed, particularly as regards the cleanliness of the steel, to secure a perfect adhesion of the two metals, and a correct action of both limbs.

Melting in a coal fire (which I have seen done) is very objectionable, and the fumes of coal-tar interferes with and prevents the union of the metals.

In addition to a carefully turned plug of slate-pencil, a little wet chalk or pipe-clay will prevent the brass from entering the hole, which is indispensable to be preserved good, as upon its accuracy the truth of the balance mainly depends, and of both limbs thereof acting equally. The use of an enameller's furnace should be of considerable advantage (a gas furnace in particular), such as Bruton and Boulter's, for instance.

Many balances are spoiled by being *over-heated*, but in such a furnace, directly the brass is in a proper state of fusion, the green flame is seen, and then the sooner it is taken out the better. I was informed by Dr. W. H. Wallaston, that the elder Breguet gave the preference to having a film of gold between the steel and the brass. This is very easily to be accomplished.

An (almost) instantaneous immersion of the steel in muriatic acid (spirit of salts), or a *strong* solution of sal ammoniac, cleanses steel very perfectly for the adhesion of any metal to it, but it must be very quickly rinsed in water. That which has been boiled is best, being most free from air.

If it is then put into a strong solution of gold (moderately hot), it will take a very good coat, after which, with a camel-hair brush, cover it with borax that with water has been ground fine upon a piece of slate, let it dry by a gentle heat, and it is ready for the furnace.

For those who are not conversant with dissolving gold, and preparing a solution, it is the best way to send the steel to a gilder who possesses the knowledge of doing it.

One most important point of an apparently insignificant nature that has, I find, escaped the attention of some of the first-rate Compensation balance makers, is deserving of notice.

Many years since, after heating a piece of steel to a blue, that had been turned perfectly true, it proved to be quite oval (or rather worse). I then turned it quite true again, when to my surprise, after heating it to a blue, it again became oval. I then took another piece of steel, about one inch and three-eighths long, from the same bar, and while at a blood-red heat, closed the grain at each end upon an anvil: Yet, after the hammering and turning it *true*, it did *not continue* true upon bluing again. The next piece I hammered more, but that did not turn out quite correct, clearly showing that the steel as obtained in the bar requires to have the ends well forged and carefully connected before using; and, still further, of proving the absolute necessity of trying a balance by *poising* it in various degrees of temperature after it is cut open, to see if *both* limbs act equally. For pocket chronometers that are expected to be timekeepers, I scarcely need say that attention to that important point is imperative. Those who do not go to the expense of having those important (as well as some few other) minutiæ carefully attended to, must be prepared to meet with disappointments.

Pendulum.

The points urged against Harrison's Gridiron Pendulum are—

Firstly,—The weight of the *upper* part of the pendulum, with its frame and nine solid rods, with their weight so much above the centre of oscillation, has always been disliked.

Secondly,—The heavy pressure of the pendulum-ball upon the top of these rods.

Thirdly,—Imperfect adjustment of the Compensation by pins at various distances.

These are objections that are universally admitted.

The question now arises—How are they to be obviated? In answer, I say:—

Firstly,—To remedy the above evils, I have devised means of obtaining the requisite amount of Compensation in less than half the length of Mr. Harrison's, and at one-fourth the weight.

A light but strong rod has always been desirable.

Secondly,—I have devised means of taking off the pressure from the top of the rods by the use of spiral springs, or any elastic substance—india-rubber tubing, for instance. Mr. John Ellicott had previously used steel springs for the same purpose to his pendulum.

Thirdly,—I have effected the adjustment of the Compensation by means of nuts and screws at the top ends of the tubes, which I use in preference to solid rods, so that the Compensation may act simultaneously with the pendulum's main rod and the suspension-spring.

Fourthly,—I have constructed an adjusting mechanism to alter instantaneously the length of the pendulum requisite for solar or sidereal time, and *vice versa.*

It is effected thus: The pendulum is raised from its mean-time bearing by a snail, similar to the one used for the strike and silent work of an eight-day clock, and by turning it nearly half-way round, it raises the pendulum on to a strong detent, which is adjusted for sidereal time, which, being adjusted and once got right, never requires to be disturbed, but will remain permanent.

When the clock requires to be removed, and perhaps to a different latitude, recourse must be had to the adjusting nut at the bottom of the pendulum-rod, near the top of the stirrup. It is very easy to raise the "bob" of the pendulum of a clock that is showing mean time to sufficient weight to bring it to sidereal time; but that takes many days (and sometimes weeks) to effect, whereas by my mechanism, the same thing can be done in less than five minutes. My attention was directed to this subject by Captain Kater, and also by Sir Frances Baily, but I could not succeed with it to my satisfaction until recently.

Fifthly,—By placing the tubes "strut" fashion instead of perpendicular, they draw the pendulum-ball or "bob" to a greater height for any given increase of temperature than what they allow it to descend for a corresponding decrease of temperature, upon the same principle that my double-action balance causes the weights to traverse the distance on the periphery to or from the junction of the laminæ to the bar.

Sixthly,—By placing the lenticular "bob" horizontally instead of vertical, I obtain greater momentum, by concentrating the mass of weight as much as possible near the centre of oscillation. For the rod I use a piece of French clock-spring. It is *light*, strong, and cheap.

That the column of mercury is not acted upon simultaneously with the rod and suspension-spring upon change of temperature is so clearly manifest that it would be an insult to common sense to say more upon the subject.

Having contrived a pendulum whose Compensation should act simultaneously with the variation of strength of the suspension-spring

and length of the rod, my attention was next directed to the production of a Compensation that should act simultaneously with the balance-spring of a chronometer.

Thus, from the year 1815 to the present time, this has been the most *arduous* and perplexing task that I have ever been engaged upon, and at a *much greater* cost than would readily be believed; independent of abstracting my attention from the regular plodding and money-making course of the business, which I had a first-rate opportunity of doing.

The various contrivances which I have hitherto invented and made to effect the desired object have been more expensive than what was likely to be countenanced by the trade; but by what I have got in hand and in contemplation, I feel satisfied that I shall not only be able to effect at a more moderate cost, but be able to make an alteration upon the Compensation without *stopping* the chronometer, and by making use of a screw with 100 turns to the inch, to make very minute alterations upon it to the sixtieth part of a turn.

P.S.—The laminæ of some balances that were made by Mr. Owen Robinson, for the elder Mr. Arnold, were tapered, similar to that described in the *Horological Journal* for December, 1873, but that there was not so much steel used in proportion, and a considerable portion of silver in their composition. They were exceedingly stiff, also very sensitive, and gave very great satisfaction.

Germany. — A new coinage law was passed by the German Reichstag on the 23rd of June last, supplementing the law of the 4th of December, 1871. By it a gold piece of the value of five marks, as well as a silver piece of the same value, were added to the proposed coinage, and also a silver two-mark piece, the adoption of which was only carried by a narrow majority, owing to the apprehension that it might lead to the importation of a larger amount of Austrian florins into Germany. The Federal Council, in pursuance of this law, gave directions for proceeding in the first instance with the coinage of marks and of pieces of 20, 10, 2, and 1 pfennigs, in addition to the 20-mark and 10-mark gold pieces, the coinage of which had been in progress since 1871.

The light gold coin imported into the Mint for re-coinage during 1873 amounted to £950,075, as against £778,000 in 1872, and the Bank of England are again the only importers.

RAILWAY INSURANCE CHARGES.

It will be remembered by many of our readers that about six years ago the council of the British Horological Institute represented to the Board of Trade the excessive rates charged by railway companies for the insurance of watches against loss in transit. In reply to the memorial of the council the Duke of Richmond, then president of the Board of Trade, said the Government contemplated bringing under the consideration of Parliament the provisions of what is known as the Carriers Act. It may be as well to say that by this act railway companies are relieved from responsibility in case of the loss of parcels of more than £10 in value containing watches, clocks, precious stones, gold, silver, silk, china, glass, or paintings, unless the value has been previously declared and insurance paid thereon. Now the rate of insurance charged has been simply prohibitive, and consequently parcels even of great value are sent uninsured, causing an amount of anxiety to the sender, to which he ought not to be subjected, and occasionally entailing an almost ruinous loss. A few months back the National Chamber of Trade endeavoured to get better terms by appealing to the railway companies themselves.

The companies were asked to arrange between them a uniform code of charges for insurance, irrespective of distance, and upon a much lower scale than the average of that hitherto adopted. By the courtesy of the National Chamber of Trade, we are enabled to annex the result of this application to the railway managers:—

" *Revised Classification and Scale of Charges for Insurance of Goods, from 1st January,* 1875.

BY PASSENGER TRAIN.

PARCELS UP TO £1,000 IN VALUE.

Distance.	Declared value up to £20.		Declared value up to £40.		Declared value up to £50.		Declared value up to £75.		Declared value up to £100.	
	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.
Up to 100 miles	1	0	2	0	2	6	3	9	5	0
„ 150 „	1	3	2	3	3	0	4	6	6	0
„ 200 „	1	6	2	6	3	6	5	3	7	0
„ 300 „	1	9	3	0	4	0	6	0	8	0
„ 400 „	2	0	3	6	4	6	6	9	9	0
Above 400 „	2	6	4	0	5	0	7	6	10	0

No less charge than as for £20 parcels above £100 in value to be charged on the above basis, by adding the fractional parts shown in the foregoing Table to the charge for the first £100; thus for a parcel of £120 the scale of £100 is to be charged, plus that for £20.

arcel of £420, four times the scale at £100 ged, plus that for £20.

above £1,000 in value to be charged as at iz.—First £1,000 to be charged according ve scale, the remainder at half rates. The les of charges for bullion to remain as at

BY GOODS TRAIN.

icles.	For every £100 Sterling of Declared Value. Distance.	Charge.
		s. d.
rs, clocks...	Not exceeding 200 m.	5 0
epieces	201 to 350	10 0
d articles...	351 and upwards......	15 0
china from		
turers	Minimum charge......	2 6
l and silver,		
....	Not exceeding 200 m.	10 0
anufactured		
anufactured	201 to 350	20 0
nd jewellery		
nufacturers	351 and upwards ...	30 0
silver, plate-		
d china, not		
nufacturers	Minimum charge......	5 0
e lace and		
gs		
tones, wat-		
d jewellery	Not exceeding 200 m.	20 0
manufac-		
rinkets ...	201 to 350	40 0
s, title deeds		
....	351 and upwards ...	60 0
exchange,		
notes, or		
for payment		
y, English		
n	Minimum charge ...	7 6
and pictures		

tions of £10 *to be calculated as* £10.

rance to be effected until the Insuring have, by inspection, by a competent behalf of the Company, satisfied them- t the articles are in accordance with the n, and are in good condition, and well

the above table it appears that the es adhere to the old system of mile- t they have agreed to adopt a uniform ch is something less than the average e charged, but is still absolutely ve. Any advantage in the change, is more than counterbalanced by racticable proviso that the Company fore insuring, ascertain by inspection articles to be insured are such as represented.

lear, then, that no real relief can be without parliamentary interference. tion taken by the Railway Companies ore difficult to understand, as it is he present practice of sending valua- sured has an injurious effect on the f their servants.

THE NEWCASTLE TIME GUN.

AT the half-yearly meeting of the North of England Horological Association recently held, Mr. D. Reid, President of the Association, in the course of an interesting paper on "The Time Gun," said:—Formerly each town possessed its own local time, or as you like to call it—longitudinal time. Upwards of thirty years ago a movement was originated in Newcastle to urge other towns to keep one time—namely, Greenwich mean time. Of course much inconvenience was experienced in each town having a time of its own, and when railways came into existence it was worse still. The movement, as I said, originated in this town, and I claim credit on behalf of the firm (Reid and Sons) to which I belong, that it was not without a good deal of correspondence and trouble before we could get the most important towns to conform to one time. It was eventually agreed to, and of the various contrivances introduced to notify to the public the correct or true standard time, I think none have fulfilled the purpose so well as that of the time-guns. Formerly there was no way of signifying it except in a very crude way. Many years ago I understand that the time was brought down by the guard of the coach from London once, or perhaps twice a week, and a blunderbuss was fired on the Sandhill or Quay at a given time each week. There again have been time-balls and semaphores; but these do not attract attention so much as a good report of a gun. I believe that the gun has proved so much of a success, that many of our chief seaport towns, and even inland towns, have adopted it. It is of much importance to a shipping place like Newcastle and Shields, where captains can determine the error of their chronometers and enable them to make observations correctly at sea. The matter of the time-guns of Newcastle and Shields, you will have observed by our local papers, has been before the public bodies with reference to their being maintained. The Newcastle gun has been stopped from firing for some little time on account of some old and decayed buildings, as it was greatly feared these buildings would not stand, and a representation has also been made by the various proprietors of property adjacent to the Castle, that the gun was doing much damage if allowed to go on. This opposition to the gun being fired closely adjacent to the old portion of the town seems to have greatly alarmed the corporate authorities. I can quite understand that some of the members of our public bodies

have made such absurd speeches respecting the gun, and so misrepresented facts, and as there seems no one to contradict them, I think it is only fair that the public should be put right with regard to this useful institution. I would not think of troubling to go into the merits or demerits of the time gun had I not, in conjunction with other gentlemen, been instrumental in introducing it into Newcastle. The other parties were—Professor Smyth, of the Royal Observatory, Edinburgh; Mr. N. J. Holmes, electric engineer, and Mr. Graves, representing the Electric Telegraph Company at that time; that was 11 years ago, and at the meeting of the British Association held in Newcastle in 1863 we inaugurated the time gun. Its introduction was looked upon as a great novelty, as I do not think any other town in England had then adopted it, and with the exception of Edinburgh, I think Newcastle was the first town in the kingdom to try the experiment. The matter was then brought before the Tyne Commissioners, and the gun had a warm friend and supporter in the late Mr. James Mather, of South Shields. I believe it is owing to the success of the gun in Newcastle and Shields that other towns have followed suit. The main purpose of the guns was to indicate to the shipping the exact time at Greenwich, as, without that, ships that touch here having chronometers require to determine the error to enable the captains to find true longitude at sea, and when you think how much depends upon that, and the valuable cargo and lives frequently entrusted to the captain's care, I think the least we can do is to cheerfully give our united aid—I mean the various towns on the Tyne—to maintain so valuable an acquisition as the time daily indicated by the guns of the Tyne. It would appear by several of the speeches before our local bodies, viz., before the Town Council, and even the Tyne Commissioners, that it had all along been an expensive plaything, and that it had not answered the purpose it was intended for, and that gentlemen whose timekeepers were not always correct had always found fault with the gun, rather than with their watches, and that it was always wrong, but not their watches. To any one who took an interest in maintaining the accuracy of true time, it is positively impossible to detect an error in the gun except by a fine astronomical clock and transit instrument. Barring an accident in the discharge of the gun, I can speak for the accuracy of the time gun, having noted it daily from its first commencement, and I can say that with few exceptions—and these have been accidental and also the result of thunderstorms—that it has kept time with marvellous accuracy, having compared it with daily observation by astronomical regulator and a large number of ship chronometers. Without these instruments and a transit instrument it is absurd of any one to imagine they can detect any fractional portions of seconds, or even a second. I do not know where those parties rest their proofs that the time gun has kept incorrect time, and has been useless to ship captains. My own experience is quite the contrary, and I know that it is frequently used by ship captains and others; and captains of steam vessels too, which can only call or stay a short time, have availed themselves frequently of it, the same as they do at any other ports. I trust that these few facts will disabuse the public of much misrepresentation regarding the gun which has lately been talked before our local bodies. I am quite sure the public look with unfeigned regret upon the fact of the "gun time" being done away with, and if it is for want of a better site and safer away from old buildings, by all means let it be moved to a more eligible place, but do not let it go forth that the gun had failed in its object, but rather that we had failed to secure a proper site for it.

ABSTRACT OF THE REPORT OF THE DEPUTY MASTER OF THE MINT

(C. W. Freemantle, Esq.),

FOR THE YEAR 1873.

(*Continued from page* 59.)

A successful attempt has been made during the past year in the Island of Trinidad to substitute a currency of British silver for the old foreign silver coins which had up to that time circulated in the colony. The details of the substitution are reported in a despatch from Governor Longden to the Secretary of State for the Colonies, dated the 23rd of July, of which a copy was, by their lordships' directions, forwarded to me for my information. The total nominal value of the foreign coins received into the Colonial Treasury, under a notice issued by the Government, was £7,734 11s. 8d., and those coins when sold realised the sum of £6,930 0s. 5d. The loss on the transaction, therefore, did not exceed £804 11s. 3d., or 10·40 per cent., exclusive of the incidental expenses for freight, &c., which amounted to £146 19s. 1d., and the Governor, in reporting that the change effected in the currency of the Colony will be a great advan-

the community, is fully justified in that the price at which the advantage n obtained is not exorbitant.

returns, not already referred to, which ated in the appendix, are in the same that adopted for the year 1872. The account, first compiled for 1872, s on one side a complete statement of enses incurred in connection with the ncluding the amount paid for superan- and compensation allowances, and the iture charged to the Office of Works tionery Office on account of the de- nt, during the year, and on the other erent receipts of the department pay- the Exchequer. The result shows e operations of minting during the 73 produced a net gain (or excess of over expenditure) of £40,564, as £98,313 in 1872. The amount of r loss in the operations of the Mint rily depends almost entirely upon the of silver and bronze bullion purchased verted, at a profit, into coin ; and the al reason for the large amount of profit accrued in 1872 as compared with to be found in the fact that in the year the silver bullion purchased was ,848, and in the latter only £522,957.

arrangement of the coins and medals ng to the Mint, including those pre- by the late Sir Joseph and Lady Banks, n completed, and a descriptive cata- as been compiled, with their lordships' n, by Mr. William Webster, of Hen- Street, Covent Garden. The whole on is now open to the inspection of blic in the Museum attached to the partment, and is interesting as illus- of the successive changes in design cution which the British coinage has one from the time of the Saxon kings present day. Among the coins of interest in the collection may be men- a shilling of Henry VII., which marks ortant change in the design of the coinage, namely, the substitution of al shield of arms for the cross with s" at the angles, which had up to me formed the reverse of the coins, strates the great advance in art made this reign. Other coins of great nu- ic interest are, the "Oxford crown," k of Thomas Rawlins, chief engraver Mint during the civil war, which is a series of coins and medals by the rtist struck at Oxford before its sur- by the Royalist forces in 1646 ; and brated "petition crown" by Thomas who was chief engraver of the Mint under the Commonwealth, and whose petition to be retained in that office at the Restoration occupies the rim of the coin.

I pointed out in my first annual report that the gold standard trial plate prepared in 1829, and then in use, was below the exact standard of fineness, and further, that it might be well to supplement it with a plate of fine gold. Their lordships having, in accordance with this suggestion, requested the Board of Trade to take the necessary steps for the preparation of new standard plates both of gold and silver, and for supplementing them with plates of fine metal, it was decided that the Mint should undertake the preparation of the plates, and that the Goldsmiths' Company should be requested to verify their accuracy. It should be borne in mind that, as portions of the plates are distributed to the provincial assay offices in the country, and to the Indian and Colonial Mints, both their preparation and verification are matters of the highest importance.

I had hoped, as mentioned in my report for 1872, that the preparation and verification of the new trial plates would have been completed before the usual time for holding the trial of the pyx in the following year. I found it necessary, however, on the 30th of June last, to intimate to the Warden of the Standards that it would not be possible to complete the necessary arrangements before the 17th of July, the day fixed by their lordships for the trial, and I explained the reasons which had led me, though unwillingly, to that conclusion. I found that, although no effort had been wanting to prepare accurate plates within the period which it had been anticipated would be sufficient for their completion, and although three out of the four plates to be prepared had been completed and were ready for delivery, the difficulties attending the preparation of the plate of standard silver had not been entirely overcome. These difficulties, as has been repeatedly pointed out, are caused by the physical phenomena which attend the union of silver with copper, and I was obliged to report that it had not been found possible to bring to a satisfactory conclusion the delicate and tedious experiments connected with the preparation of this plate. So peculiar, indeed, is the molecular structure of the silver-copper alloy, that it may be doubted whether a plate composed of silver and copper in the proportions prescribed by law can with advantage be put forward as a correct standard of reference ; and, while therefore it appeared undesirable to alter the arrangements for testing the accuracy of the coinage which had

existed for many centuries, and which had been embodied in the Coinage Act of 1870, it was proposed that the standard plates should be supplemented by plates of as nearly as possible absolute purity.

The reasons for this recommendation are fully explained by Mr. Roberts, but it may be well briefly to state the manner in which standards are used in assaying, the process being a rapid chemical analysis, the results of which indicate with a high degree of accuracy the relative amounts of precious and base metals present in the alloy under examination. In the assay of gold and in the dry assay of silver, the base metal is in the first instance eliminated from a known weight of alloy, and the amount of fine metal remaining is then accurately determined by weighing. The details of the operation, however, are complicated, and the accuracy of the result may be affected by many causes. It is necessary, therefore, to submit to assay, side by side with the alloys to be tested, pieces of "standards" of known composition; but, as any error in the composition of the "standard" used will be reflected in the result, it is preferable to use as a check an amount of absolutely pure metal corresponding in weight to the amount of the pure gold or silver supposed to be present in the alloy. It is evident how great an advantage lies in the use of checks of pure metal when it is considered that, while the attainment of uniformity of composition in an alloy of two metals is almost impossible, the preparation of pure gold and pure silver does not offer insuperable difficulties.

Plates of gold and silver of standard fineness as directed by the Coinage Act, and supplemental plates of pure metal, were finally placed in the hands of the Warden of the Standards, and submitted to the Goldsmiths' Company for verification on the 22nd of December last. The examination made at Goldsmiths' Hall was conducted with due regard to the importance of the issue involved, and proved the purity and accuracy of all the plates.

In June, 1873, a new coinage law was passed in Norway, establishing a single gold standard, with precisely the same gold coins as those adopted by Sweden and Denmark. As regards silver coins, the Norwegian two-crown and one-crown pieces are identical with the same pieces in the Swedish and Danish systems, but it has been resolved, instead of adopting the decimal sub-division of the crown, to maintain the old arrangement of dividing it into 30 skillings, and to coin pieces of 24, 15, 12, and 3 skillings. It is to be feared that this resolution will lead to much inconvenience, as precluding the free international circulation of Norwegian coins with those of Sweden and Denmark, but it may be hoped that the Storthing will eventually agree to join the Convention, and thus complete the establishment of a monetary system common to all three countries.

The Safe Use of Steam. Containing Rules for the Guidance of Unprofessional Steam Users. By an ENGINEER. London: Lockwood and Co.

THIS admirable little book aims at dissipating the very general ignorance that prevails among owners of steam-engines respecting the principles and the construction of their boilers, &c., and appears calculated to attain its end, being written so clearly as to be understood by all who will read it attentively. There is, however, rather a profusion of technical terms in inverted commas, some, indeed, so technical as to be unknown to many engineers. The only advantage we can see in cutting off a guage-glass from the inside, as the author recommends—instead of from the outside—is the difficulty of accomplishing it. A rule to ascertain the proper amount of lifting for the valves of the feed-pumps—taking into consideration the size and the speed of the ram—would have been valuable information; but to say that "from $\frac{3}{16}$ths to a $\frac{1}{4}$ of an inch is generally sufficient," is too general, and would be misleading. The author lays proper stress upon the evil of allowing any joints about a boiler to leak even ever so slightly, although the steam user might just as well have been told the tendency to leak is often caused by the wretched engineering which so arranges pipes that they cannot expand freely.

THE *Hampshire Advertiser* says a Winchester jeweller has for inspection a valuable example of English watch-making, which once marked time for an Indian potentate. It has a duplex escapement, and repeats the hours, &c., and is made by the firm of McCabe, of London. It was the property of the finder, General Abbot, an old Indian soldier, and bears the annexed commemorative inscription :—"This watch was found in the tent of Akbar Khan after the action fought in front of Julalabad, April 7th, 1842."

tters to the Editor.

s to be addressed to the Editor, at the tute, 35, Northampton Square, E.C.

itor of THE HOROLOGICAL JOURNAL.

ISOCHRONISM.

'Onus Probandi" has favoured me ply, but I really am uncertain what , because I can take his reply two

s, a spring is not perfectly elastic, ch reacting force is somewhat less force which acted on it—this is eed, it is said there is no known in nature that is perfectly elastic ; tly the inference I possibly might this part of his letter is, that a nnot produce an isochronal motion nced wheel through variable angu- .

another part of his letter he says, ng is to the balance that force that to the pendulum." Now, if this n hypothesis might be started that is capable of producing isochronal f a balanced wheel, precisely the Dr. Hooke's theory of isochronism, if the spaces to be described are al to the weights which make m with the tension of the spring, of the motion would be equal.

sir, that "Onus Probandi" does his way clear in this matter; my saying so is because he cannot see learly without he understands the between a mechanical power and nd it is very unusual for a person understand the difference, to try them, because he must be well will signally fail.

lraw a pendulum on one side from ; point, the earth's attraction op- doing so, and, when we release the earth's attraction will operate endulum with the same force it our drawing it on one side, minus from extraneous resistances ; and, t for these resistances, the pendu- d rise to an equal height on the the lowest point ; hence we have law of the simple pendulum, pro- were subject to no extraneous re- r impulse, that when once set in oscillations would go on for ever , and performed in equal times. n we move a balance round on its alance-spring resists our doing so, but when we release the balance the spring will *not* operate as a motive power to the balance with the same force it resisted our moving it round, not even if there was no friction or resistance of any kind, because the spring is a mechanical power that has got to move the mass of which itself is made, as well as whirl back the balance, and a part of its force is employed in moving its own mass, and, therefore, is not *all* employed in giving motion to the balance ; what part of its force is so employed it is impossible to ascertain, but it would be different with different material, such as gold, or steel, the gold being much heavier than the steel. Furthermore, it is characteristic of a mechanical power, such as a spring, that its energy of operation diminishes, as the body acted on recedes faster from the spring's action.

In small machinery of watches, where the balance collet by which the balance is whirled is very small, having very little velocity, and the material of which the spring is made is very small too, we see that if we move round a balance, say 180° from the quiescent point, the balance will vibrate round nearly 180° on the other side ; nevertheless it is not so near as it would be if the spring restored to the balance *all* the force it took to wind up the spring, minus extraneous resistances.

Dr. Hooke has frequently been cited as an authority in the matter of an isochronal property of spiral springs by persons who have not known his argument is a failure ; his theory is based on an assumption that a spring restores to a balanced wheel *all* the force it takes to wind round the wheel and spring, and it does not do so, hence his theory fails ; but in Dr. Hooke's time it does not appear there was any notice taken of the difference between gravity and mechanical and animal powers, so it is no wonder he should have overlooked the matter ; but more is known now, and explained by some of the chief writers on mechanics.

Before closing this letter, I would remark that many persons make use of the word isochronism without properly understanding the nature or order of the motion they are using it to. Mr. Butter, in his spelling-book, says the work is derived from the Greek, *Isos*, which means equal, and *Chronos*, which means time ; hence we say isochronous, or equally timed, and thus the meaning of the word is very clear. But to be time there must be some kind of motion, and the word does not express what kind of motion it is to be applied to ; meaning

nothing more than equal times, it can be applied to any kind of motion in which the times are equal. For instance, the uniform daily motion of the earth is isochronous; a body moving with an accelerated and retarded motion in a cycloidal arc is isochronous; but these, although they are different kinds of motion, yet they are motions of simple bodies, that is, they are not a machine.

In the case of machinery, such as watch or clock works, the pendulum and balance are under the action of two forces, which frequently vary in their effect; nevertheless we may say the vibrations are isochronal, provided the times are equal, and the train wheels are isochronal too, for they perform their revolutions in equal times; indeed, it is only by their being isochronal that we know the long and short arcs of the balance are equally timed.

So, what with the *bonâ fide* isochronal motion of bodies moving in cycloidal arcs, and Dr. Hooke's hypothesis of the isochronism of balanced wheels whirled by springs, and this other sort of isochronism of machinery, it is necessary for a person who wants to have correct notions on the subject, to clearly understand the nature or order of the motion he is using the word isochronism to, or he may get puzzled over it: we have only to look through the literature of watchmaking to find abundant proof of the vagueness and misunderstanding on the subject, simple as it is.

Yours &c.,
UNIQUE.

SIR,—After "Onus Probandi" had presumed to criticise and denounce Palmer's Essay, I asked him, through the November number, for the information of the readers of the Journal, to supplement his remarks that "the laws of isochronism are determined by the length of the spring for giving equal time in the long and short arcs of vibration" by stating the length of spring possessing that property, or how such a length could be obtained, and also to define what he intended by the equilibrium of the balance *by which the timing is to be done*. In the December number of the journal "Onus Probandi" deigns no information regarding the first point, and in reference to the other matter, professes to understand my question to be, that he would define the meaning of the word equilibrium. Assuming that when "Onus Probandi," by means of your Journal for October, denied Mr. Palmer's conclusions in such stinging and unmeasured terms, he really intended to convey something by the words I quoted, I trust he will have the courtesy to endeavour to make his meaning clear to the readers of the Journal.

Yours, &c.,
F. E.

THE COMPENSATION ERROR.

SIR,—In reading Mr. Crisp's essay, I came across a valuable piece of information, viz., the mention of tables published by the Astronomer-Royal proving that, with an uncompensated balance, the loss in heat to take place steadily and uniformly; a certain fixed loss or gain corresponding exactly to any one degree of temperature. This, of course, does away with the theory that the balance-spring loses its elastic force in some accelerated ratio which, I confess, was quite an article of faith with me, as it was with many others who, like me, had not the advantage of knowing anything about these tables. It is, therefore, solely in the balance that the cause of the middle-temperature error must be looked for, but the simple contraction and expansion in heat and cold does not account for it. There is no reason why the rims, being parts of circles and of a uniform thickness, should not retain a perfectly circular form when affected by heat or cold, and if this is the case, it is quite certain that the compensation weights approach the centre quicker as the temperature rises than they recede from it as it falls again, and the error should, therefore, be the other way. Any one of your readers may satisfy himself upon that point by referring to an admirable enquiry into the motion of compensating weights in action by Mr. R. Webster, in No. 67, vol. vi., of the *Horological Journal*. It was in consequence of this fact being proved beyond any doubt that watch-makers imagined an error in the spring in excess of that in the balance, the latter taking place in the right direction, but not to a sufficient extent.

With these tables before us, this rather convenient way of reasoning can no longer be adhered to, and it is my belief that the true cause will be found in the centrifugal force exerted by the balance, causing the weights to "fly out" at the quickest part of the vibration, and by that means considerably affecting the long and short vibrations, which was so forcibly pointed out to your readers by Mr. B. Dennison, of Bradford, in the July number of last year. If the balance-rims are very thin it may become a matter of impossibility to attain isochronism. Chronometer timers are well aware that

every alteration of the weights necessitates a re-adjustment of the spring, and leave, therefore, isochronism till the compensation is perfect, or nearly so.

It would be interesting to know the exact extent to which this centrifugal force retards the vibrations. I have not had time to make experiments in this direction, but I think it must be considerable; and as at each vibration the elasticity of the rims is put in requisition, their power of resistance, as well as their restitutive force, must necessarily be impaired by heat; the rims enlarge more than in cold, and retard the vibrations to such an extent as to *more* than counteract the balance error, and all the more so from the notorious fact that the vibrations themselves considerably augment in heat.

I very much question whether the good performance of such balances as Kullberg's and Hartnup's is not mainly due to the fact that their form and construction offer less scope for the display of the centrifugal force.

In consideration of the general interest felt just now in the subject of compensation, you will, perhaps, find a place for this in the next number of the Journal.

M. IMMISCH.

DRUM TIMEPIECES.

SIR,—The tendency of drum timepieces to stop for want of power, of which your correspondent "Plymouth" complains, is a very common one, and arises, of course, from defective caliper, the barrel not being large enough to allow a proper length of sufficiently strong spring. The evil may, however, sometimes be remedied, and the timepiece be made to go the last few days, if the power be economized so as to reduce the locking and impulse pressure. I have many times succeeded in overcoming the difficulty by altering the shape of the pallets, as shown

by the annexed sketch. If the dotted lines represent the original form of the pallets, then the alteration consists in reducing the circular part or locking pallet, leaving but a slight impulse plane on the same, and making the opposite one so long as to equalize the drop.

Yours &c.,

R. T.

SIR,—I should advise "Plymouth" to examine well all wheels, to see if any tooth is bent, or has burr left to stop it. Also to diminish the thickness of escape and fourth wheel, say to one-half. Also to reduce the size of the escapement pivots, and polish them well. Sometimes the wheels want topping or rounding up.

Yours &c.,

A. D.

SIR,—In reply to "Plymouth," respecting the stopping of these timepieces, I beg to inform him, that provided the depths, endshakes, &c., are correct, as he states, there is only one method of cure—which is to put a new pair of pallets, embracing more teeth of the escape-wheel. By this means the escape-wheel will command a greater leverage over the pendulum, and consequently maintain its vibrations with less power. I usually file off the original pallets, and fit on the arbor a new pair, embracing five teeth, which never fails to make them perform the full time. If the third and fourth wheels are unnecessarily thick, it is well to reduce them considerably, so as to diminish the friction on the pinions.

Yours, &c.,

J. E. M.

Chard.

"A. FROMANTELL."

SIR,—In reply to Messrs. Reid and Sons' question as to the date A. Fromantell was living, the following account of him is from Edward Wood's "Curiosities of Clocks and Watches":—"A pendulum clock was, however, made by Richard Harris, a London artist, for St. Paul's Church, Covent Garden, in 1641 or 1642. Inigo Jones, the architect of this church, having been in Italy while Galileo was living, possibly communicated to Harris what he had heard there of the pendulum. It is, moreover, stated that the first pendulum clocks made in England were constructed by John Fromentel (or, as variously spelt, Fromantil, Fromanteel, and Fromantil), a Dutchman. Evelyn, in his diary, under date May 3rd, 1661, records that he returned

by Fromantels's, the famous clockmaker, to see some pendules." The *Commonwealth Mercury* of Thursday, November 25, 1668, contains the following advertisement on this subject, by which it would appear that the mechanician's first name was not John, and that all the dates above enumerated are incorrect:—

"There is lately a way found out for making clocks that go exact, and keep equaller time than any now made without this regulator, examined and proved before his Highness the Lord Protector, by such doctors whose knowledge and learning is without exception, and are not subject to alter by change of weather, as others are, and may be made to go a week, a month, or a year, with once winding up, as well as those that are wound up every day, and keep time as well, and is very excellent for all house clocks that go either with springs or weights; and also steeple clocks that are most subject to change of weather. Made by Ahasuerus Fromanteel, who made the first that were in England. You may have them at his house on the Bankside, in Mosses Alley, Southwark, and at the sign of Mere Maid, in Lothbury, near Bartholomew Lane end, London."

Again, Evelyn says, under date Nov. 1st, 1660, "I went with some of my relations to Court to show them his Maj^{ties} cabinet and closet of rarities. . . . Here I saw . . . . amongst the clocks one that showed the rising and setting of the sun in Y^{e} Zodig, the sunn represented by a face and raies of gold upon an azure skie, observing Y^{e} diurnal and annual motion rising and setting behind and landscape of hills, the work of our famous Fromantel."

I am, sir, &c.,
W. B. CRISP.

To Correspondents.

Will some of your correspondents have the goodness to tell me through the medium of the Journal, the proper method of using the touchstone, in ascertaining the quality of a piece of gold? Also I have a good lever watch, which will go say for a month, and keep good time, then on taking it out of the pocket some day I will find it an hour or two back, but still going. It must of course have been stopping, and I apprehend the fault to be in the escapement. Perhaps some one will kindly give their opinion as to what may be the probable cause, and by doing so, they will greatly oblige an old subscriber.—G. S. W.

Can any of your readers give me any information respecting a Geneva watch I have. It loses time in the pocket, and gains time laid down.—A CONSTANT SUBSCRIBER.

Can any reader inform me of the method employed by John Gottlieb Ulrich to unmagnetise the balance and pendulum-spring, as mentioned in his Essay on Compensation, in the December number of the Journal?—J. E. M.

JOBBER.—*Who sympathises with "Plymouth" in the difficulties he has with drum timepieces, will observe that the question has received the attention of two correspondents. We read Jobber's letters with much pleasure, and share his desire that the Journal shall be the means of conveying practical information to the younger members of the trade.*

E. B. PARKES.—*We think you are right. Graham may possibly have thought of the lever escapement, and the Abbé Hautefeuille is mentioned as having invented it about* 1720, *but the practical application is undoubtedly due to T. Mudge, who made a lever watch for Queen Charlotte about* 1770, *while Peter Litherland did not obtain his patent for the rack lever till* 1794.

J. J. P.—MR. B. L. VULLIAMY *died in* 1854, *at the age of seventy-four.*

P. M.—*All the back volumes of the Journal, except I., VIII. and IX., are in print. There is no separate index published.*

GILT.—*Pinchbeck, who discovered the alloy of metals closely resembling gold, lived in Clerkenwell in* 1721, *and afterwards in Fleet Street. There is a description of Ferguson's paradox in one of the early numbers of the Journal.*

TYRO.—*Plumbago has been used with some success as a lubricant for clock pivots.*

F. J.—*The elder Arnold died in* 1799.

G. V. S., ST. JOHN'S WOOD.—*The time spent on your device for causing pendulums to describe a cycloidal curve is simply wasted—there is so little difference between the cycloid and the circular arc for small vibrations, a fact to which attention has been drawn over and over again, although apparently without effect; besides, pendulums when swinging from a spring, do not really move in the arc of a circle, but quite as nearly in a cycloid as practice demands. Read Denison's work.*

British Horological Institute.

The Half-yearly General Meeting of the Members for receiving the Report of the Council and the transaction of ordinary business was held at the Institute on Tuesday, January 12th, 1875.]

Mr. JOHN JONES, F.R.G.S., Vice-President, presiding.

AFTER reading the minutes of the previous General Meeting, the Secretary read the Report and Balance Sheet appended:

"*Report for the half-year ended December 31st*, 1874.

"The Council have much pleasure in reporting the continued prosperity of the Institute. Three of the chief sources of income—the members' subscriptions, the sales of journals, and the advertisements—have been more productive during the half-year than in any other similar period since the existence of the Institute.

"Since the last report of the Council the Institute has had to lament the death of Mr. Klaftenberger, a member of the Institute from its establishment, and a vice-president for 14 years. During the early days of the Institute Mr. Klaftenberger was one of its most energetic supporters, and was at all times conspicuous for his generous, kindly, and conciliatory disposition.

"The prize of fifty pounds which the Council were enabled, by the kindness of the Baroness Burdett-Coutts, to offer for the best Essay on the Compensation Balance, fell to Mr. W. B. Crisp, by the unanimous award of the adjudicators. In the exercise of the right held by the Council, Mr. Crisp's essay has been published in the Journal. Some of the other essays sent in competition are also being published by permission of the authors, whose good feeling and courtesy the Council desire to acknowledge.

"The Council have much gratification in being able to report the satisfactory state of the classes under the direction of the Secretary. The classes are larger and show a better average attendance than at any other time since the Institute has been favoured with the assistance of the Goldsmiths' Company.

"In September an opportunity was afforded to the members of inspecting Woolwich Arsenal—a privilege of which about 70 availed themselves.

"Discussion meetings were held at the Institute on November 11th and December 8th, awakening so much interest that the Council desire to ask of the members generally their assistance in rendering meetings for discussing technical subjects a permanent feature of the Institute.

"Eighteen members have been elected during the half-year.

"The following additions have been made to the Library and Museum:

"A copy of Ludlam's Observations made in St. John's College, Cambridge, presented by W. Ellis, Esq., F.R.A.S.

"Two parliamentary returns relating to the Westminster Great Clock, presented by Mr. Ulrich.

"A copy of the Fifth Edition of Clocks, Watches, and Bells, and a copy of a new edition of Astronomy without Mathematics, presented by the Author, Sir Edmund Beckett, Bart., Q.C.

"A model of a tool for drilling off movements for watch dials, presented by Mr. Martin.

"By order of the Council.

"F. J. BRITTEN,

"*Secretary*."

Balance Sheet for the Half-year ending December 31, 1874.

Dr.	£	s.	d.
To Balance in Treasurer's hands at last Audit	25	12	5
" Balance in Treasurer's hands Building Fund	52	10	7
" Prize Fund (Gift of the Baroness Burdett-Coutts)	50	0	0
" Subscriptions	104	6	8
" Sales of Journals	55	11	10
" Advertisements	76	18	11
" Drawing Class Fees ...	1	15	0
" Sundries	2	12	6
" Six Months' Interest of Building Fund	1	6	5
	£370	14	4

Cr.	£	s.	d.
By Payment for Prize Essay ...	50	0	0
" Cost of Engraving Dies and Striking Medals	20	19	0
" Rent, Taxes, and Insurance	34	10	0
" Salaries, Wages, and Commissions	67	1	10
" Journal Expenses	92	11	4
" Stationery, Stamps, &c. ...	7	6	8
" Printing	1	5	0
" Journal Loan Repaid ...	10	0	0
" House Expenses	16	12	9
" Sundries	5	19	0
Balance	306	5	7
By Cash in Treasurer's hands ...	10	11	9
By Cash in Treasurer's Hands, Building Fund	53	17	0
	£370	14	4

"We have examined the above statement, together with the books and vouchers, and certify the same to be correct, this 12th day of January, 1875.

"G. H. HAWKINS.
"JAMES PYOTT. } *Auditors.*"

THE CHAIRMAN, in moving the adoption of the report and balance-sheet, said, the report of the Council had perhaps less variety of matter than usual, but it gave evidence of satisfactory progress. At the inception of the Institute, some of the members of the trade were no doubt carried away with the grandeur of the idea, and expected wonderful results which were not exactly realized, and they in consequence relaxed their labours. The Institute had passed through the depression following the first rush of energy. It had had its share of internal contention, and its times of torpidity; but now even if the labours of the Council was less, it was fairly prosperous, thanks to the energy of the secretary. The measure of success was not what they might say about themselves, but what other people said of them, and now they found their exertions in the way of technical education, and their endeavours to advance the trade generally, were receiving the countenance of the Press. Their exhibition had been warmly commended by the *Times* and other newspapers. Not only the Press, but persons and corporate bodies who were keenly alive to all matters connected with the welfare of the country, expressed their approval of the manner in which the Institute was conducted in a practical form. They had to acknowledge the valuable assistance of the Goldsmiths' Company, whose funds they all knew were invariably applied with discrimination. The members were aware, even before the report of the Council was read, of the adjudicators' decision regarding the prize offered for the best essay on the Compensation Balance, but he mentioned it in order to acknowledge their obligation to the Astronomer-Royal, Sir Charles Wheatstone, and Mr. Walsh, who undertook the task of deciding the relative merits of the papers sent to compete.

Lady Burdett-Coutts, by whose liberality they were enabled to offer the prize, had recently given another instance of her willingness to assist them by offering to contribute one-half of a sum required to pay for an essay on Isochronism. Mr. Cole was now growing in years, and the Council felt it would be an advantage if they could through their Journal place before the members the results of his long experience. Subject to some details, an agreement had been entered into, and he thought that not the least pleasing thought of Mr. Cole would be that by his own essay he had contributed to the information of the trade in which he had attained such eminence. On all hands they received congratulations respecting the improved appearance of their Journal and of its contents. The only incident of the half year calculated to call forth feelings of sorrow was the loss they had sustained by the death

. Klaftenberger, who endeared himself with whom he came in contact. As his and speech implied, he was not a native s country, but he adapted himself with facility to the habits of Englishmen, and d into the affairs of the Institute with y and good feeling, making his loss a r of sincere regret to them. There red no other point in the report re- ig comment. They were going on well, would, no doubt, gradually attain a on of distinction.

. JACKSON (treasurer) said he could se the remarks of the chairman as to vancement of the Institute, particularly rence to his particular branch. Finan- they were making steady progress. ordinary sources of income were more c, and, supplemented by the handsome of the Baroness Burdett-Coutts and the miths' Company, enabled them to pro- or the intellectual wants of the trade ntly. He thought, however, there was oom for more members, and suggested n invitation to co-operate might with tage be sent to many members of the throughout the country. He had pleasure in seconding the motion of doption of the report and balance-

. BICKLEY thought the progress of the ute might well be indicated by the one fact that they were out of debt. He ected that when he joined the finance ittee they were heavily indebted to the r, and in addition to being under the aging influence which accompanies they were continually hampered in action for want of means. The chair- ad taken a right view in attaching the tance he did to the countenance of the As a constant reader of the *Times*, d observed a desire on its part to sup- uch institutions as theirs. Mr. Walter, in the course of an inaugural address he delivered at the Quebec Institute, ted in the *Times* of November 25th, quoting from a report furnished to the nment by our foreign consuls, said, is workmen are competent in their l trades, and take an interest in their for, thanks to their superior education, fully appreciate the pecuniary advan- to their masters and indirectly to them- by adhering strictly to this course. king instance of the impolicy of acting wise has lately happened at St. Imier, in ernese Jura, and produced a deep im- on. In this district, for some years a great falling off in the quality of the watches manufactured has taken place, owing to the inhabitants finding it much more profitable to increase the production at the cost of the workmanship than to abide by the old rules of the trade. They prospered beyond all expectation for a considerable time, but finally their watches got such a bad name that they became unsaleable, and the result is a general bankruptcy of nearly all the watch manufacturers of this district." This technical education for watchmakers (continued Mr. Bickley), imparted by the government in Switzerland, was in England left entirely to the Horological Institute, and it was against the tendency to degrade watch-making from its position as an art that the Institute had struggled for years. But the other day the council of Trades Unions were discussing the practicability of giving technical education. All were agreed as to its necessity, but appeared equally at a loss for a method of application; while here the Institute had a scheme in practical operation for years, as far as their own trade was concerned.

Mr. GLASGOW agreed with Mr. Bickley that the determination to maintain the high character of English work was really sound commercial policy. He thought it a pity that England had allowed the clock-making to go elsewhere to the extent it had without an endeavour to produce really good clocks by machinery. He was glad to observe a willingness among members of the trade to give practical information through the Journal when asked for—that spirit of exclusiveness and silly mystery was less apparent, although he was afraid that one or two communications he had lately read were penned in a spirit of insincerity. He thought that if a special invitation were issued to country members of the trade it should be accompanied with a copy of the Journal as evidence of the work the Institute was really engaged in.

The motion for the adoption of the report and balance-sheet having been carried unanimously,

The CHAIRMAN moved a vote of thanks to the Auditors (Mr. James Pyott, and Mr. G. H. Hawkins), who had given their services willingly and gratuitously for years, which was seconded by Mr. Jackson, and carried.

The CHAIRMAN said that during the half-year an incident had occurred which was not mentioned in the report because it was as yet unsettled. An application had been made by the Post Office authorities to the Institute to pay rent in future for the wire by which they obtained the time-signals from Greenwich. Their president, Sir Edmund Beckett,

had drawn for them a memorial to the Postmaster General, to which an unfavourable but somewhat unintelligible reply had been received. However, as they hoped to carry the matter further, he need not more particularly allude to it; he simply rose to propose that they should thank their President for what he had already done in the matter. Gratitude had been described as "a keen expectation of future favours," and it was just possible they would have to trouble the president again in the matter. In any case, he did not think his proposition would be out of place.

The vote of thanks to the president having been seconded and carried,

A vote of thanks was accorded to the secretary, for his exertions on behalf of the Institute, on the motion of Mr. Jackson.

Mr. JAMES U. POOLE had much pleasure in proposing that the thanks of the meeting be tendered to the chairman, not only for presiding that evening, but for the interest he invariably manifested in the welfare of the trade.

Mr. BACON gladly availed himself of the privilege of seconding Mr. Poole's motion, which was carried enthusiastically.

The CHAIRMAN, in acknowledging the compliment, mentioned the stride made by the Turners' Company as an instance of what might be done by perseverance. He said it had always been a pleasure for him to do what he could for the trade, and expressed his gratification that the Institute had made such progress.

TELEGRAPHING TIME.—The following is the manner of giving correct standard time to all the telegraph stations, 255 in number, on the main line and branches of the Philadelphia and Reading road:—At three minutes to 4 o'clock p.m., daily, except Sunday, all business along the line is suspended; and by means of a series of repeaters all the lines of this company, thirty-six in number, are arranged so as to be operated and controlled by one operator at the Reading office, who has a chronometer before him, from which the correct time is given. Commencing at three minutes to 4 p.m., the operator says "time" on the lines, which calls the attention of all operators to adjust their clocks, and is continued at short intervals until five seconds to four, when he opens the circuit. At 4 o'clock he makes one tap; at fifteen seconds after 4, two taps; at thirty seconds after 4, three taps; at forty-five seconds after 4, four taps; and at one minute after 4, five taps.—*Iron.*

British Horological Institute.

LIST OF NEW MEMBERS.

AUSTEN, —, Watch Maker, 18, President-street, E.C.

BAKER, JOSEPH, Lever Escapement Maker and Watch Manufacturer, Woodstock, Oxon.

BEUTHIN, JOHN CRESWELL, 3, Regent's-park-terrace, N.W.

BOWEN, A. O., Watch Manufacturer, Ripley, Derbyshire.

CORKER, H. D., 6, Dartmouth-terrace, Forest-hill, E.C.

DICKESON, FREDERICK, 8, Turl-street, Oxford.

GARDNER, R., Junr., Lochbrae, New Kilpatrick, Dumbartonshire.

HARDY, S., 13, Thavies-inn.

HARRIS, W. L., Watch Maker, 35, Skinner-street, Clerkenwell, E.C.

HOLLAND, W., Chronometer Maker, Rock Ferry, Birkenhead.

LANG & SÖHNE, A., Watch Manufacturers, Glashütte, Saxony.

LUND, & BLOCKLEY, Messrs., Watch Manufacturers, 42, Pall Mall, S.W.

MARSH, THOMAS, Watch Maker, Dorking, Surrey.

PARKIN, E. A., The Chantry, The Close, Exeter.

RICHARDS, J. H., Watch Maker, 57, North Main-street, Wexford.

SMITH, G., Clock Maker, Osmaston-road, Derby.

TAYLOR, JOHN, Junr., Watch Maker, Dunning, N.B.

WEBB, ARTHUR WILLIAM, Springer and Timer, 4, Pullin's-row, Islington.

WILLIAMS, T. J., Chronometer Maker, 2, Bute-dock, Cardiff.

GLASGOW GOLDSMITHS' COMPANY.—A special meeting of the wardens and members of this company was held yesterday forenoon—Mr. Wm. Alexander in the chair—for the purpose of electing two wardens in the room of Messrs. David Sutherland and Andrew Kelly, deceased. The meeting unanimously appointed Messrs. William Taylor and William Alexander, and agreed to send letters of condolence to the widows and families of the deceased wardens. A committee was appointed to draw up rules for the charitable society in connection with the members of the company, and report at the annual meeting in July.

THE LEVER ESCAPEMENT.

(SECOND PAPER.)

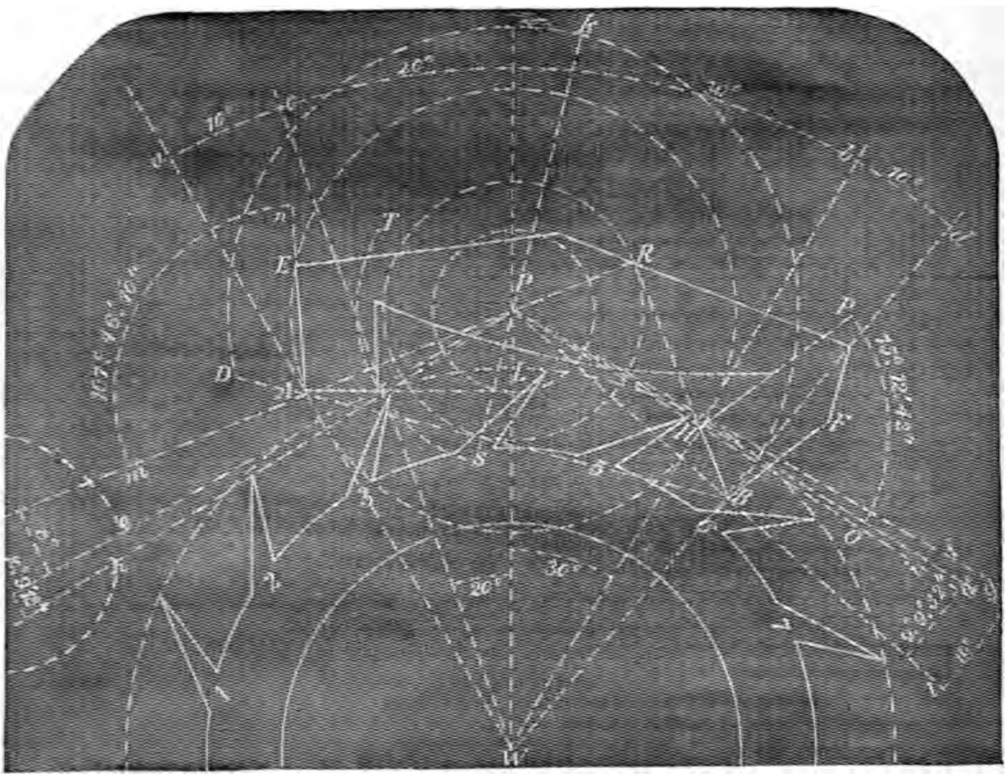
BY JOHN FEWTRELL.

I HAVE to apologize for the long delay in the appearance of my papers, but I was obliged to lay them aside by more urgent demands on my leisure hours, and was rather reluctant to recommence them until I saw your "Notice to Correspondents" in the Journal for November.

The following calculations and diagrams are for pallets with "equidistant lockings," and will, I hope, be readily understood. Given :—Radius of wheel = 1 ; angular breadth of pallets = 10° ; drop = 2° ; locking angle = 2° ; impulse angle = 8° ; run = 1° ; recoil of wheel during unlocking = 30′.

Distance of centres and radius of locking circle :—Draw a circle round the wheel-teeth and the line of centres W P, and 30° on each

(FIG. 1.)



side ; draw lines a and b, and through the joints where a and b cut the wheel-circle, draw the tangents e and f at right angles to a and b, where these tangents cross each other, and the line of centres at P is the centre of pallets, and W P is the distance of centres, and it requires but a very elementary knowledge of trigonometry to know that W P is the secant of 30° = 1·1547, and the radius of locking-circle P B = tangent of 30° = 0·57735, and are obtained directly from the tables of sines, tangents, &c.

In the diagrams the radius of wheel = 2 inches, hence W P = 1·1547 × 2 = 2·3094 in., and radius of locking-circle = ·57735 × 2 = 1·1547 in.

Radius of inner and outer circles. Draw the lines c and d 10° to the right of a and b, and from P as centre, through the points where c and d cut the wheel-circle, describe the

inner (S T) and outer circles (A K B), and through the same points draw the lines h and g.

To calculate the radius of inner circle we have given a = distance of centres = 1·1547005, b = radius-wheel = 1, and the included angle C = 20°, and require $< B$, and side C.

$$\text{Tan. } \frac{A-B}{2} = \frac{a-b}{a+b} \text{ Cotan. } \frac{C}{2}$$

$$\frac{A+B}{2} = 90^\circ - \frac{C}{2}$$

$$B = \frac{A+B}{2} - \frac{A-B}{2}$$

$$C = \frac{\text{Sine C}}{\text{Sine B}}$$

The above formula is used in most of our examples, and need not be repeated; inserting the values given we have

EXAMPLE 1.

$1·1547005-1=·1547005 \text{ log.} = \bar{1}·1894917$

$1·1547005+1=2·1547005 \text{ log.} = 0·3333869-$

$$\text{Log. } \frac{a-b}{a+b} = \bar{2}·8561048$$

$$\frac{C}{2} = 10^\circ \text{ log. cotan.} = 10·7536812+$$

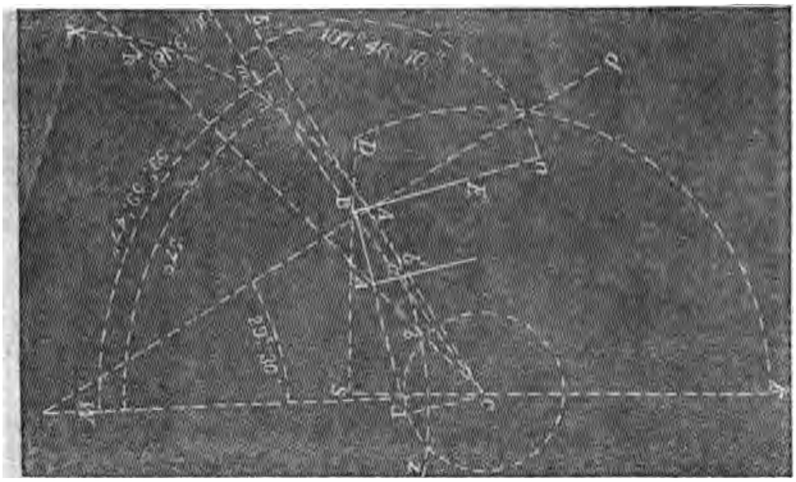
$$\frac{A-B}{2} = 22^\circ\ 9'\ 18'' \text{ log. tan.} = 9·6097860$$

$$\frac{A+B}{2} = 90^\circ - 10^\circ = 80^\circ\ \ 0\ \ 0$$

$$\frac{A-B}{2} = 22\ \ 9\ \ 18-$$

$$< B = 57\ \ 50\ \ 42=$$

(FIG. 2.)



angular distance of line h from line of centres.

$$\text{Log. sine } 20^\circ = 9·5340517$$

$$\text{Log. sine } 57^\circ\ 50'\ 42'' = 9·9276839-$$

$$C = ·4039873 \text{ log. } \bar{1}·6063678$$

Rad. inner circle = ·404.

For the radius of outer circle the sides of the triangle are the same as for inner circle, but the included angle is 40°.

EXAMPLE 2.

$$\text{*Log. } \frac{a-b}{a+b} = \bar{2}·8561048$$

$$\frac{C}{2} = 20^\circ \text{ log. cotan. } 10·4389341$$

$$\frac{A-B}{2} = 11^\circ\ 9'\ 32'' \text{ log. tan.} = 9·2950389$$

$$< B = 90^\circ\ (11^\circ\ 9'\ 32''+20) = 58^\circ\ 50'\ 28'' =$$

* Obtained from Example 1.

Angular distance of line g from line of centres—

$$\text{Log. sine } 40^\circ = 9·8080675$$

$$58^\circ\ 50'\ 28'' = 9·9323595-$$

$$c = ·7511177 \text{ log.} = \bar{1}·8757080$$

Radius of outer circle = 0·75

Radius of impulse circle, 1st pallet:—Draw line m P 8° from e (this is the impulse angle), and from the point B where line m crosses the locking-circle, draw the impulse plane to the point where the inner circle S T and line e cross the wheel-circle, and prolong it to L and let fall the perpendicular P L, Fig 1, and C L, Fig 2; this is the radius of lifting or impulse circle.

EXAMPLE 3, FIG. 2.

Given :—Angular distance of line m P from line of centres . . = 68° 0′ 0″
Ditto, ditto, line h . = 57 50 42 —

< C = 10 9 18

a = Rad. locking = ·5773503
b = Rad. inner circle = ·4039873
·5773503—·4039873 = ·173363
·5773503 + ·4039873 = ·1813376

$$\text{Log. } \cdot 173363 = \bar{1}\cdot 2389564$$
$$\text{Log. } \cdot 9813376 = \bar{1}\cdot 9918184—$$

$$\text{Log. } \frac{a—b}{a+b} = \bar{1}\cdot 2471380$$

$$\frac{C}{2} = 5^\circ\ 4'\ 39''\ \text{log. cotan.} = 11\cdot 0513348+$$

$$\frac{A—B}{2} = 63^\circ\ 17'\ 59''\ \text{log. tan.} = 10\cdot 2984728$$

$$< B = 90^\circ—(63^\circ 17'\ 59'' + 5^\circ 4'\ 39'') = 21^\circ\ 37'\ 21''$$
$$\text{Log. sine } 21^\circ\ 37'\ 21'' = 9\cdot 5663752$$
$$\text{Log. } \cdot 5773503 = \bar{1}\cdot 7614394+$$

$$c = \cdot 212723 \text{ log.} = \bar{1}\cdot 3278146$$

Rad. lifting-circle = ·2127 × 2 = ·4254 = line C L Fig. 2, or P L Fig. 1, which latter is on the line of centres.

Radius of lifting or impulse circle, 2nd pallet :—Draw line i 2° from f; this is the locking-angle; and draw line l 10° from g; this, minus the 2° of locking, is the impulse-angle = 8°.

From the point A, where line l cuts the outer circle, draw the impulse plane to the point where line i cuts the locking-circle and prolong it to R, and let fall the perpendicular P R Fig. 1 and C R Fig. 2; this is radius of lifting-circle, and for the calculation we have—

EXAMPLE 4, FIG. 3.

Given :—a Rad. outer circle = ·751117, b = Rad. locking circle = ·5773503, angular distance of line i from line of centres . . = 58° 0′ 0″
Do. do. of l = 58° 50′ 28″—10° = 48 50 28 —

< C = 9 9 32

$$\frac{C}{2} = 4\ 34\ 46$$

$$\frac{\cdot 751117 — \cdot 5773503}{\cdot 751117 + \cdot 5773503} = \frac{\cdot 1737667}{1\cdot 3284673}$$

$$\text{Log. } \cdot 1737667 = \bar{1}\cdot 2399666$$
$$\text{Log. } 1\cdot 3284673 = 0\cdot 1233509—$$

$$\text{Log. } \frac{a—b}{a+b} = \bar{1}\cdot 1166157$$
$$\text{Log. cotan. } 4^\circ\ 34'\ 46'' = 11\cdot 0937095+$$

$$\frac{A—B}{2}\ 58^\circ\ 21'\ 41''\ \text{log. tan.} = 10\cdot 2103252$$

$< B = 90° — (58° 21′ 41″ + 4° 34′ 46″) = 27° 3′ 33″.$

$$\text{Log. sine } 27^\circ\ 3'\ 33'' = 9\cdot 6579258$$
$$\text{Log. } \cdot 751117 = \bar{1}\cdot 8757080+$$

$$c = \cdot 34169 \text{ log.} = \bar{1}\cdot 5336338$$

Radius of lifting-circle ·34169 × 2 = ·68338 = line P R Fig. 1, and line C R Fig. 3.

I may here make a few remarks upon the grave error Mr. Grossman made in measuring the impulse-angles from the tangents e and f instead of the lines g and h, that is, from the periphery of the wheel.

An inspection of diagram Fig. 1, will show the error in first pallet to be 2° 9′ 11″, and as he only assumes a locking-angle of 1° 30′ the tooth of wheel would drop 39′ 18″ on impulse-plane.

The error on 2nd pallet is only 1° 9′ 32″, but this substracted from 1° 30′ leaves but 20′ 48″ as the locking-angle.

It is really very unfortunate, as the error is so obvious, that Mr. Grossman did not detect it at once, as it renders his tables, &c., quite useless, and it is but a poor consolation to us that he DID detect it in time for his French edition.

Height of segment :—Draw the line A B, joining outer corners of pallets, and prolong it to the outer circle at D; bisect it in S, and draw the line S P K, which is the height of segment.

EXAMPLE 5.

Given :—Angular distance of line m from line of centres - - 68 0 0
Ditto, ditto, line l - 48 50 28+

< C = 116 50 28

$$\frac{C}{2} = 58\ 25\ 14$$

a = radius outer circle = ·751117
b = radius locking-circle = ·5773503

As the sides a and b are the same as in Example 4, we obtain from thence

$$\text{Log.}\ \frac{a-b}{a+b} = \bar{1}\cdot1166157$$

$$\frac{C}{2} = 58^\circ\ 25'\ 14''\ \text{log. cotan.} = 9\cdot7886701+$$

$$\frac{A-B}{2} = 4^\circ\ 35'\ 51''\ \text{log. tan.}\ 8\cdot9052858$$

$<B = 90^\circ - (58^\circ\ 25'\ 14'' + 4^\circ\ 35'\ 51'') = 26^\circ\ 57'\ 55''$

$<A = (90^\circ - 58^\circ\ 25'\ 14'') + 4^\circ\ 35'\ 51'' = 36^\circ\ 10'\ 17''$

Log. Sine $26^\circ\ 57'\ 55'' = 9\cdot6565298$

Log. $\cdot751117 = \bar{1}\cdot8757080+$

$c = \cdot3405946$ log. $= - \bar{1}\cdot5322378$

Rad. outer circle . . = ·751117
·3405946 +

Height of segment . . = 1·0917116

Ditto, ditto in diagram . = 2·1834232

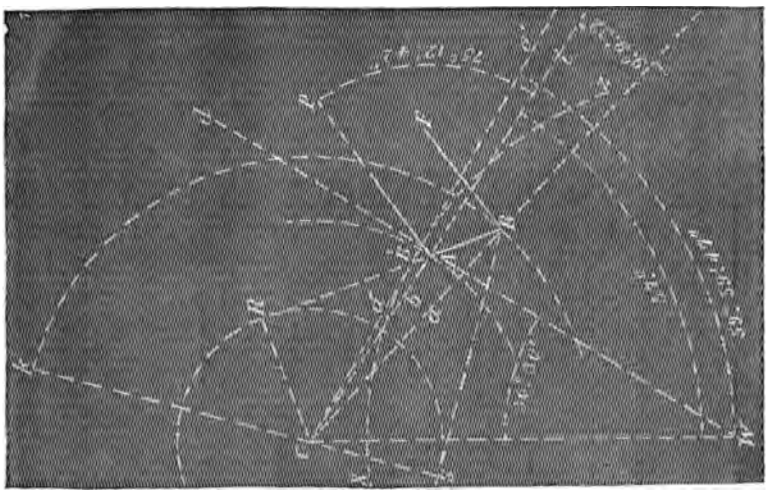
Draw angle, 1st pallet Fig. 2. The pallet is supposed to be 3° within the wheel circle, that is 2° locking and 1° run, and the wheel tooth is also supposed to have advanced 30′ towards the line of centres, and would "recoil" the same 30′ during the unlocking. The arc x z is the wheel circle, and W C the line of centres, the line d is drawn 29° 30′ from the line of entries, and line b′ is drawn through the point where it cuts the wheel-circle; we have now to calculate the length of line b′ to the locking-face, and its angular distance from the line of centres.

EXAMPLE 6.

Given :—Dis. of centres = 1·1547005
Radius wheel, = 1, < C = 29° 30′

$$\frac{C}{2} = 14^\circ\ 45'$$

(FIG. 3.)



From Example 1 we obtain

$$\text{Log.}\ \frac{a-b}{a+b} = \bar{2}\cdot8561048$$

Log. cotan. $14^\circ\ 45' = 10\cdot5795854+$

$$\frac{A-B}{2} = 15^\circ\ 15'\ 13''\ \text{log. tan} = 9\cdot4356902$$

$<B = 90^\circ - (15^\circ 15' 13'' + 14^\circ 45') = 59^\circ 59'\ 47''$

Log. sine $29^\circ\ 30' = 9\cdot6923388$

Log. sine $59^\circ\ 59'\ 47'' = 9\cdot9375145-$

Log. $568623 = \bar{1}\cdot7548243$

EXAMPLE 7.

We have now another triangle, of which the two sides and the included angle are given: a = radius of locking = ·5773503 and b′ = ·568623.

Angular dis. of line b′ = 59° 59′ 47″
Ditto pallet corner = 57 0 0 —
< C = 2 59 47

$$\frac{C}{2} = 1\ 29\ 53$$

·5773503—·568623 = ·0087273
·5773503 + ·568623 = 1·1459733

Log. ·0087273 = $\bar{3}\cdot9408799$
Log. 1·1459733 = $0\cdot0581744-$

$$\text{Log.}\ \frac{a-b}{a+b} = \bar{3}\cdot8827055$$

Log. cotan. $1^\circ\ 29'\ 53'' = 11\cdot5825007+$

$$\frac{A-B}{2} = 16^\circ\ 16'\ 17''\ \text{log. tan.} = 9\cdot4652062$$

$= 90° — (16° 86' 17'' + 1° 29' 53'') = 72° 18' 50''$

0 0
13 50—

46 10 = arc m n Figs. 1 and 2.

53 9 nat. sine = ·8078327
2

rd 107° 46' 10'' = 1·6156654

om A as centre, and with 1 in. as radius, ibe an arc m n, and lay off the distance from m to n, and draw the locking- A E towards n, and the inner face lel, and the 1st pallet is complete.

Exam. 5 = S A P, Fig. 1 = 36° 10' 17''
Exam. 7 = P A E, Fig. 1 = 72 13 50

Draw angle = S A E = 108 24 7

aw angle 2nd pallet, Fig. 3. The pallet ain supposed to be 3° within the wheel, ine d is now 30° 30' from line of centres, ine a' is drawn through the point where s the wheel circle. We have now to late the angular distance of line a' from of centres, and the radius of wheel and nce of centres are the two given sides, 30° 30' the included angle.

EXAMPLE 8.

om Example 1 we obtain

$\text{Log.} \frac{a-b}{a+b} = \bar{2}\cdot8561048$

$= 15° 15'$ log. cotan. $= 10\cdot5644243 +$

$= 14° 45' 13''$ log. tan. $= \bar{9}\cdot4205291$

$= 90° — (15° 15' + 14° 45' 13'') = 59° 59' 47''$

Log. sine 30° 30' = 9·7054689
Log. sine 59° 59' 49'' = 9·9375145—

Fig. 3 = ·5860765 log. = $\bar{1}\cdot7679544$

ven :—a = ·5860765, b = ·5773504.

Angular dis. of a' = 59° 59' 47''
Do., do. of locking = 57 0 0—

< C = 2 59 47

$\frac{C}{2}$ = 1 29 53

5860765 — 5773503 = ·0087262
5860765 + 5773503 = 1·1634268

Log. ·0087262 = $\bar{3}\cdot9408252$
Log. 1·1634268 = 0·0657391—

$\text{Log.} \frac{a-b}{a+b} = \bar{3}\cdot8750861$

Log. cotan. 1° 29' 53'' = 11.5825007 +

$\frac{A-B}{2} = 16° 0' 11''$ log. tan. $= 9\cdot4575868$

$< A = (90° — 1° 12' 53'') + 16° 0' 11'' = 104° 47' 18''$

180 0 0
104 47 18—

75 12 42 = arc o p, Figs. 1 and 3.

37 36 21 nat. sine = ·6102258
2

Chord 75° 12' 42'' = 1·2204516

From the locking corner H, as centre, with 1 in. radius, describe the arc o p, and lay off the chord 1·22 from s on line g, and draw the locking-face H p and the outer face parallel, and the 2nd pallet is complete.

< A Ex. 8 = C A p, Fig. 3	=	104 47 18
< C Ex. 8 = A C B,	=	2 59 47
< C Ex. 4 = A C B,	=	9 9 32
< B Ex. 4 = A B C,	=	27 3 33
< B H p	=	144 0 10
		180° 0' 0''
		144 0 10—
< H B F	=	35 59 50
< A B C	=	27 3 33
< A Ex. 5 = S B P	=	36 10 17
Draw angle = S B F	=	99 13 40

I have gone through the calculations very carefully, and hope they will be found correct, but if there is anything at all obscure, I shall be happy to give any further explanations.

JOHN FEWTRELL.

Birmingham.

IT is said, but upon doubtful authority, that clocks were known in Geneva in the ninth century, and that the art of manufacturing them was imported there from Germany. The bell or sounding part of the machine was added some time after; and in the eleventh century clocks were not uncommon. However this may be, it seems tolerably certain that the trade of clock and watchmaking in Switzerland is of considerable antiquity; and it has remained until now as a staple branch of that country's manufactures.

ESSAY ON THE COMPENSATION BALANCE

USED IN CLOCK AND WATCH WORK FOR COUNTERACTING THE INFLUENCE OF TEMPERATURE.

BY F. KUNDSEN.

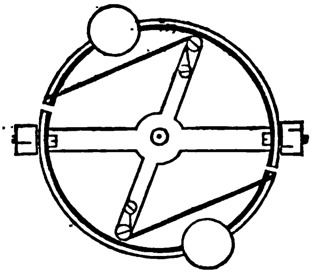
THE balance of a portable time-keeper is the part of the instrument that measures time, and if time is to be measured to perfection all the vibrations of the balance must be performed in the same length of time. But independent of irregularities that may arise from the train and escapement, the vibrations of a balance are influenced by changes in temperature. Metals are weaker and more expanded in heat than in cold, and through the expansion of the balance alone, watches went about twenty seconds per day slower in summer than in winter, and this imperfection greatly increased after the invention of the balance-spring, when, in addition, a rise in temperature weakened this long and slender spring that regulates the vibrations of the balance. The first invention made in England for the correction of errors arising from temperature was about the year 1768, by a British horologist, named Harrison. It was known some hundred years previously that brass expands and contracts more by changes in temperature than steel. Of this knowledge Harrison availed himself, and by joining a thin slip of brass to a thin slip of steel he formed a laminæ, which, on account of the greater expansion of the brass, by increase in heat, bent to the side of the steel, and *vice versâ*. This he put in connection with the index, and by a proper arrangement he succeeded through changes in temperature in moving the index sufficiently towards fast or slow to make his watch keep the same rate in different temperatures. Harrison's watch by these means became a valuable instrument in finding longitude, and he was rewarded by a Government grant of £20,000.

But although Harrison's invention was a great improvement, it was defective, as any alteration in the acting length of the balance-spring destroyed the isochronism of the vibrations of the balance; and as about the same time a French horologist, named Berthoud, invented a better way, by expansions and contractions of the balance, his invention has been adopted, and is now used in all superior watches and portable clocks. The correction for temperature is called the "compensation"; and a balance used for this purpose is therefore called a "compensation balance." The compensation balance has, however, undergone some modifications since it was first invented; and it is now generally made in the following manner:—

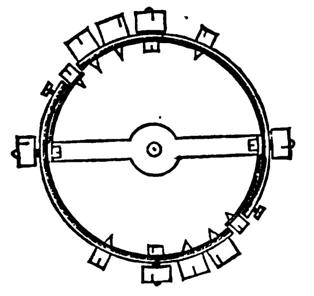
A piece of steel is turned to a proper size; and after it has been covered with borax, and the hole is stopped with chalk or black lead, to prevent it from getting filled with brass, it is put into a crucible with as much brass as may be required for covering it when melted. The brass, in melting, unites to the steel, and the piece is afterwards, by turning and filing, reduced to two arms of steel, and a standing-up ring composed of brass and steel, with the brass outside, and of about twice and a half the thickness of the steel. This ring is cut through in two opposite places, at a little distance from the arms, and on the two moveable parts of the ring, which are called the rims, are placed, opposite to each other, two pieces of brass of equal size and weight, which have a groove that fits on the rims, where they are held fast in their positions by a screw from the inside. These are called the compensation weights, and are about one-half of the whole weight of the balance. Brass, in heat, expands more than steel, and when the temperature rises, and the balance-spring becomes weaker, the rims bend in, whereby the compensation weights are carried nearer to the centre, and by a proper adjustment of these weights, which pass through a greater space the nearer they are placed to the end of the rims, a watch or chronometer can be made to keep the same rate in different temperatures, or, as it is generally called, in heat and cold. In watches and small chronometers used as pocket watches, and frequently in the larger kind, called marine chronometers, instead of two weights, screws with heavy heads are used, placed in a series of screw-holes made in the rims. A compensation balance has also a screw tap at the end of each arm, on which is put a screw nut made of brass or platina, and half way between these are likewise screw taps, or studs, with screw nuts. These screws are called the timing and position

screws, and are used for regulating the chronometer to time, and for making it go alike in different positions. When a balance has compensation weights, a position screw made of platina can be put in each of the compensation weights. Figs. 1 and 2 represent the two forms of compensation balances, with auxiliaries, which will be hereinafter described, attached to them.

(FIG. 1.)



(FIG. 2.)



The velocity with which a balance vibrates is a compound of the strength of the balance-spring and size and weight of the balance, and ordinary watches are regulated to time by altering the length of the balance-spring. But as this way of regulating destroys the isochronism of the vibrations, chronometers have no index, but are regulated by the timing-screws, by which the centre of gyration is brought nearer to or further from the centre of motion. If the screws are screwed in, the balance moves quicker, and *vice versâ*. If the balance is always vibrating in the horizontal position, the best vibration is a turn and a quarter. But it is better for a pocket chronometer that the vibration is a little more or a little less, because on account of the action of the escapement the side friction on the balance-pivots becomes altered, which causes a variation in the rate of a chronometer when going in different positions. But if the balance vibrates more than a turn and a quarter, by making the balance a little heavier in the part that is upwards in the position in which the chronometer goes slowest, or a little heavier in the lower part, if the vibration is less than a turn and a quarter, we are enabled to make a chronometer keep the same rate in different positions. But if the balance vibrates just a turn and a quarter, the screwing in or out of any of the timing or position-screws only makes the chronometer go faster or slower in every position. For this reason I consider magnetism cannot alter the rate of a chronometer when the vibration is a turn and a quarter, as the effect will be the same whatever part is turned towards the north; and that, therefore, this extent of vibration is the best for a marine chronometer or any other timekeeper in which the balance vibrates in the horizontal position.

As chronometers are made of different sizes, and the balance consequently driven by main-springs of different degrees of strength, a balance must be of a proportionate size and weight for the required degree of vibration. These are found by previous experiments. In English chronometers the different parts of the movement are always in the same proportion to the size of the frame, and with a proper main-spring and the usual resistance caused by the unlocking in the escapement, the following weights and sizes of balances may be used:—

To an ordinary 3-inch movement for a 2-day marine chronometer the ring of the balance can be $1\frac{1}{4}$ inch in diameter, and the balance may weigh about 5 dwt. 5 gr. To a movement $2\frac{1}{2}$ inches in diameter the ring of the balance may be 1 inch in diameter, and the balance may weigh about 3 dwt. 15 gr. To a 2-inch movement the ring of the balance can be $\frac{3}{4}$ inch in diameter, and the balance may weigh about 2 dwt. For an 8-days chronometer of the usual construction, with the plates $3\frac{1}{2}$ inches in diameter, the balance-ring can be $1\frac{1}{8}$th inch in diameter, and the balance may weigh about 4 dwt. 10 gr. If a balance has compensation screws, the centre of gyration gets a little further from the centre of motion; the ring can then be made as much smaller as about one thickness of the ring. As a rule, a watch or pocket chronometer that goes 30 hours can have the balance as large as the spring-barrel, and half as high, and, according to its size, it will then weigh from about two-fifths of a pennyweight to one pennyweight. If, however, a balance is a little heavier than these weights, it makes scarcely any other difference than that the balance takes a longer time to get up to its full vibration.

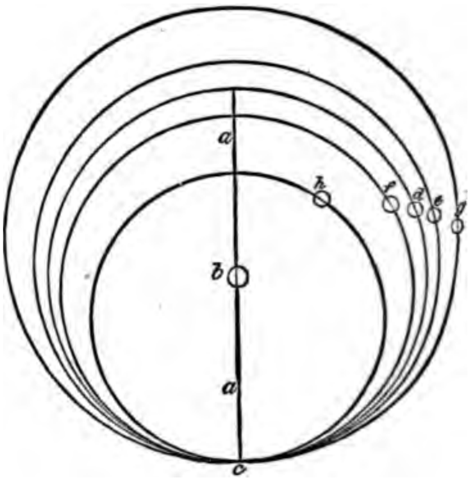
I must here observe, through causes to which I shall presently refer, the compensation is seldom perfect for great ranges in

temperature, and chronometers are therefore adjusted to go alike in the changes of temperature in which they are to be used. The best adjustment for a temperate climate is to make them go alike in 50° and 90° Fahr.; and if a chronometer is to be used in a hot climate, in 60° and 100°. The adjustment for temperature is made with the balance vibrating in the horizontal position, and cannot be relied on as being perfect unless the chronometer is kept one week in low, the next in high, and then again a week in low temperature. I must add that the rims of a balance of the size of the drawings are generally from 1-25th to 1-30th of an inch thick, 3-20ths of an inch high, with the brass 2½ the thickness of the steel, and that the compensation weights, or screws, on each rim weigh from 1 dwt. 8 gr. to 1 dwt. 12 gr. If the balance is smaller, everything is reduced in the same proportion. But to these proportions I shall refer again presently.

The imperfection in the compensation.

I have in the preceding pages given a description of compensation balances as usually made, and their adjustments; but after a balance has been carefully adjusted in the manner described there is still a residuary error, caused by temperature, and that cannot be corrected by any alteration in the positions of the compensation weights. We find that chronometers go faster in middle temperature than above or below, that the difference in rate increases more and more in extreme temperatures and in freezing, and 100° generally amounts to from four to five seconds per day. The manner in which this imperfection arises has greatly puzzled chronometer-makers, and men who have succeeded in getting a great name as horologists have not only described it as arising through balances following the same law as pendulums, but have likewise attributed it to resistance in the rims, and to the compensation weights not moving in a straight line to and from the centre of the balance. But neither of these ways of describing it can be correct. If balances followed the same law as pendulums, and the centre of gyration required to be four times further from the centre of motion to make a balance vibrate as slow again, it would have a tendency to make chronometers go faster and not slower in extreme temperatures. For if a pendulum is made a certain quantity shorter it makes a greater alteration in the rate of a clock than if made the same quantity longer; and, therefore, if the compensation weights moved sufficiently in for heat they would not move sufficiently out for cold. The consequence would be the chronometer would go faster in cold; and when the error was divided it would go faster both in heat and cold than in middle temperature. Again, if a chronometer, through resistance in the rims, went slower in heat, it would, from the same cause, go faster in cold. The compensation weights might be required a little further out on the rims than what would be necessary, if there were no resistance; but this could not make a chronometer go slower in extreme temperatures; and that it cannot be caused by the compensation weights not moving in a straight line to the centre will be seen by looking at Fig. 3.

(FIG. 3)



If *a a* represent the arms of a balance, *b* the centre and *c d* one of the compensation rims, standing circular with the centre in a middle temperature of 66°, and we suppose that rim, by a change in temperature of a certain number of degrees below middle temperature, moved out to *e*, it would in the same number of degrees above middle temperature move in to *f*; for *c e* and *c f* are of the same length as *c d* when measured along the lines, and are part of circles of which one is as much larger as the other is smaller than the circumference of the balance in middle temperature. When we now measure the distance from the centre to *e d* and *f*, we find that a compensation weight, placed on the rim, in moving from *d* to *f* must move through a greater space and approach the centre of the balance in a greater ratio than in moving from *e* to *d*; and, consequently, if the chronometer went alike in 32° and in 66°, it would go faster in 100°, and, when the error was divided, faster

in heat and cold than in middle tem-
[perat]ure.*

[It] is therefore evident that the imperfec-
[tion d]oes not arise from the balance, *but from* [the *slip*]*ping or expansion of the balance-spring* [*in in*]*crease in heat, which causes an increase* [*of th*]*e friction on the balance-pivots and* [*retar*]*ds the vibrations of the balance.* In [this,] and in no other way, can we ex[plain] it.

[Th]ere is, however, a way in which the com[pensa]tion will always be better than with ba[lance]s as usually made; and this is by giving [a greate]r angle of action to the rims in the same [degre]es of temperature. If we again refer [to fi]g. 3, and we suppose that in the same [numb]er of degrees below middle temperature [as be]fore, the compensation weight instead of [movi]ng to *e*, moved out to *g*, it would then [move] in to *h*; and when we again measure [from] the centre to *h*, *d*, and *g*, we find that [the c]ompensating power of the balance is still greater in high temperatures in [propo]rtion to low, which is the thing that is [wante]d. This additional action of the rims [may b]e obtained in three ways. The rims [may b]e made thinner, or longer, or it may be [obtai]ned by the alloy of the brass. If we [take t]he ordinary form of balance, but with [the r]ims only one half of the usual thickness, [the] compensation weights, for the same [weig]ht of balance, must be reduced by one-[third o]f the usual weight. For by measuring [on a] large scale, we find the compensation [weig]hts act to the best advantage when [place]d from 100° to 111° from the arms. the rims can also be of the usual thick- and lay flat, when there will, of course, [be r]oom to make them much longer.

[H]aving explained the true cause of the [impe]rfection in the compensation, and the [mean]s by which the compensation can be [made] perfect, it is almost unnecessary to [make] any observations on the different forms [in w]hich balances may be made, as any horo[logis]t will be able to see that the rims may [be p]laced in many ways. Still, as the sub[ject] is interesting and useful, I will give a [desc]ription of a balance invented by myself, by which I have obtained a perfect com[pens]ation.

[M]any years ago, in considering if any [furth]er improvements could be effected in [chro]nometers, I came to the following con[clusi]ons:—First, The compensation would be [impr]oved by giving the rims a greater angular action in the same temperatures; second, the rims ought never to be interfered with, and the timing and position screws should, therefore, be on independent arms. Third, the brass, being melted on the steel, ought to be hammered or compressed, by burnishing. Fourth, The laminæ ought to be bent considerably to the side of the steel, and after being bent to the proper shape, they should be heated to a pale blue colour. Fifth, To have the compensation weights always acting from the same point on the rims, they ought to be on studs. Sixth, that changes in the oil might have less influence on the rate, a balance ought to be as heavy as the pivots would carry. Seventh, long and thick rims would be stronger than short and thin. After coming to these conclusions I made a balance for a 3-inch movement, of which the following is a description:—

The arms of the balance are of steel, and from the end of one arm to the end of the other is 1½ inch. The rims are lying flat; and each rim is composed of two laminæ screwed together at one end, but perfectly free of each other. The lower laminæ has the brass on the top, and the upper one has it below. The rims commence at the end of one arm, go to the end of the other, where the rims are joined, and back to where they commence. Here a piece goes in over the arm, and carries a stud, on which is a screw nut, that weighs 1 dwt. 12 gr. These studs are 1¼ inch apart. The rims are (as near as I am able to measure) 3-20th of an inch broad, 1-30th of an inch thick, and have the brass one-and-a-half the thickness of the steel.* The timing screws are on four independent arms, fastened by two screws to the middle of the large arms, and the whole balance weighs 8 dwt. By this arrangement the rims, being about double the usual length, and about seventy-five times longer than thick, will carry the compensation weights through about three times the usual space. A chronometer with one of these balances was, several years ago, sent to the Greenwich trials, where it obtained the highest place, and kept the best rate of any chronometer ever before sent to the trials, the number of which, in the aggregate, amounted to more than 1,200. Its greatest variation during twenty-nine weeks' trial was five seconds and five-tenths, and its variation in many weeks in succession was only a fractional part of a second. I may add that I

[* T]his cannot be seen very distinctly on so small [a dra]wing; but those who will take the trouble to [comp]are on a large scale will find my statement [corre]ct.

* The brass is ordinary Birmingham brass wire. It is cut in little pieces and melted on the steel.

have adjusted other chronometers with similar balances and found the compensation equally perfect.

Chronometer-makers, through not having been able to find out the true cause of the imperfection in the compensation, or a better way of correcting it, have taken refuge auxiliaries to the compensation. But though chronometers in which I have used auxiliaries have obtained some of the highest places at the Greenwich trials, I have no great confidence in these appliances. By using an ordinary good balance-spring, and by a proper attention to the principle I have explained, chronometers can always be made to keep within a fractional part of a second, faster or slower, the same rate in freezing, and in 100°, as in middle temperature; and the compensation may therefore, for all practical purposes, be considered perfect. As, however, auxiliaries are now in general use, I will just observe that these may be made in three ways:—

The rims may be made to expand against springs, made of such a strength that they gradually give way, and placed in such a position that they cause no friction at the point of contact; or they may consist of little extra rims, fastened under the heads of the timing-screw studs, and resting against a regulating screw, from which they bend in when the chronometer begins to go slower. An auxiliary can likewise be made by a lamina screwed on the side of the balance-cock, which has a small screw at the end, that touches the balance-spring when the chronometer begins to go slower. One of the first kind of these auxiliaries, and invented by myself, is represented in Fig. 1. The screw at the end of the foot of the spring has a conical head, by which the position of the spring is regulated.

In Fig. 2 is represented one of the second kind. This can be made to act either in high or in low temperatures, by placing the brass of the rims inside or outside. These rims are generally half as high as the large rims, and a quarter as thick; and for a balance of the size of the drawing they carry a screw at the end that weighs from 2 to 3 gr. I must, however, add that I consider auxiliaries are better in low than in high temperatures; for when a chronometer has been going for some time in very high or very low temperatures the rims generally set a little, through which the chronometer alters its rate in middle temperature. If, therefore, the auxiliaries act in high temperatures, they add to this fault; but if they act in low, they retract.

THE GOLDSMITHS' COMPANY'S PRIZE.

THE designs and models sent to compete for the prizes offered by the Goldsmiths' Company, under the conditions which were published in our Journal in the early part of last year, have been placed for exhibition in the Architectural Museum, in Tufton Street, at the back of Westminster Abbey. The drawings are arranged on screens, and the models on a table, and in those cases where a prize has been awarded, the amount only is specified on a card, rendering it in some cases a matter of difficulty to decide to which of the classes the exhibit belongs, and as we were unable on the occasion of our visit to obtain any information, but such as could be gathered from the titles attached to the various subjects (the only person present representing the Architectural Museum conducting himself with marked rudeness towards visitors), we can only give the names of the prize-winners in the order their productions are placed. On the first screen from the entrance is a design for a "Testimonial," by William Clausen, of Fulham, which has carried off the prize of £50; we presume that offered for the best design for some article in gold or silver, which, when manufactured, shall exceed thirty ounces in weight. A design for a "Bridal Cup," by J. W. Sharp, of Cheyne Walk, Chelsea, has been awarded a prize of £25. Mr. W. F. Randall takes a prize of a similar amount for a design for a "Tea and Coffee Service." Mr. Owen Gibbons also takes a prize of £25 for a design for a "Centre Piece." A very elaborate design for a "Clock Case," by Mr. W. F. Randall, which receives a prize of £25, shows considerable talent; the only part, perhaps, to which exception could be taken is that devoted to the clock. As anything else but a clock-case it would have been admirable, but the dial and hands are weak in conception and altogether out of proportion to the case. A design for a "Casket," not to exceed 30 ounces in weight, in silver *repoussé* work, with filagrees in blue enamel, received a prize of £25, as does a design for a "Centre Piece," by Mr. Richard Lunn.

Throughout, the collection shows considerable artistic ability, although, all the attempts being somewhat ambitious, there is less variety than could have been desired. Considering the admirable specimens of watch-case engraving shown at the Horological Institute Exhibition, we were certainly disappointed to find nothing connected with watch-making exhibited.

Letters to the Editor.

All Letters to be addressed to the Editor, at the Institute, 35, Northampton Square, E.C.

To the Editor of The Horological Journal.

DRUM TIMEPIECES.

Sir,—In reply to "Plymouth," I have often had drum timepieces stop from want of power, the depths and freedoms being correct, and the mainspring as strong as the number of turns would allow, and have "cured" them by reducing the weight of pendulum ball and thinning the rod.

I try them first with the pendulum-ball off, and if they keep going conclude that no fault in the depths, &c., has escaped notice. I have also observed that they require to be exactly in beat and that we cannot depend on the sound alone, for they often sound in beat when the dead pallet is dipping too far into the wheel, and will stop. To put them in beat I "tip" the impulse side until it sounds considerably out of beat, and then lower it gradually until exactly in "beat." To try the increase of "arc," due to reducing the pendulum, I hold the point of a broach against the plate so that the pendulum rod just "bumps" it, and then try the escapement slowly, and notice the distance the rod is from the broach when the tooth drops, and if this distance is 2° or 3° on each side, the timepiece will not stop from want of "power." I have had several complete failures, however, when the pinions are small, and the wheels large and high numbered.

JOHN FEWTRELL.

Birmingham.

THE COMPENSATION ERROR.

Sir,—Mr. Immisch's letter in your January number induces me to make a few observations in corroboration of his views.

The Astronomer-Royal, some years ago, showed that a watch varied in changes of temperature about 6 secs. per diem for each degree of Fahrenheit's thermometer, and that this variation was in an arithmetical ratio. The correction for this error, by the compensation balance, was found to act in a geometrical ratio. These two ratios could only coincide in two points, and experience confirmed it, for if chronometers were adjusted to perform correctly in extremes of temperature, they varied in middle temperature. By actual trial it was found necessary to make the compensation weights approach the centre, for equal increments of heat, in a greater ratio than they receded from it for equal decrements. Hence, the compensation balances of Mr. Ulrich, Mr. Hartnup, and Mr. Kullberg; but this is theoretically and mathematically erroneous, for the weights ought to approach the centre for equal increments of temperature in a lesser ratio than they recede.

Let us take the pendulum as an example. The length of a second's pendulum is 39·15 inches from the point of suspension to the centre of oscillation. Let this be lengthened 1 inch. Then a pendulum of 40·15 inches will vibrate 59·25 times in a minute, and if shortened 1 inch will make 60·78 vibrations, or if lengthened 1 inch it will lose 18 minutes per diem, and if shortened 1 inch it will gain 18 minutes 43·2 seconds; showing a difference of 43 seconds between lowering and raising the centre of oscillation 1 inch from the normal point. Therefore, it ought to be raised less than 1 inch to make it gain 18 minutes, or the centre of oscillation ought to approach the point of suspension in a slower ratio than it recedes from it.

Now the same law applies to the balance. The time of vibration of a pendulum varies with the square root of the distance between the centre of oscillation and the axis of suspension. The time of vibration of a balance varies with the square root of the distance between the centre of gyration and the axis of rotation. The balance-spring is much more sensitive to changes of temperature than the pendulum. A 1 second's pendulum, with iron rod, loses 3 seconds per diem for 10° rise of the thermometer, but a watch loses 60 seconds for an equal change of temperature.

As with the pendulum, so with the balance: the centre of gyration ought to approach the centre of the balance in a slower ratio in heat than it recedes from it in cold. Then, why is it in practice that we find it necessary to adopt a diametrically opposite system, and make the weights approach the centre faster in heat and recede from it slower in cold? It manifestly can be nothing else but the effects of centrifugal force.

The laminated rims of a compensation balance are springs, fixed to the arms, and weighted. These rims obey the laws of all other springs: they become weaker when heated and stronger when cold, consequently the centrifugal force has a greater effect in heat than in cold; and this increased centrifugal error in heat, and diminished centrifugal error in cold, is so great as not only to annul what may be called the geometrical error, but to cause a much greater error the other way.

What inferences are to be drawn from the above reasoning? Clearly, that the rims of the balance should be made thicker. The rim of Mr. Kullberg's balance is double the thickness of an ordinary balance, and it appears certain that if a balance of the ordinary construction were made sufficiently rigid to overcome the centrifugal error, that no better or simpler balance could be used.

A certain amount of centrifugal error is necessary to counteract the geometrical error, and the thickness of the rims can only be ascertained by trial; but of this I am fully assured, that if the laminated rims were sufficiently rigid to be uninfluenced by centrifugal force, all compensation balances, of whatever kind, would have to be so constructed that the weights should approach the centre slower than they recede from it, unless the geometrical error were found to be so small as to be inappreciable.

The geometrical error, as shown above, is twenty times greater in the balance than in the pendulum.

I am, &c.,
R. WEBSTER,
Queen Victoria Street.

IN 1560 Tycho Brahe possessed four clocks which indicated hours, minutes, and seconds; the largest had but three wheels, the diameter of one of them being three feet, and containing twelve hundred teeth, a proof of the imperfect state of clockwork at that period. Brahe also observed irregularities in his clocks dependent upon changes in the atmosphere.

To Correspondents.

For the benefit more especially of apprentices and young members of the trade, space will be devoted to any enquiry for information on subjects congenial to the character of this Journal, however rudimentary the desired information may be; but we must ask correspondents to refrain from asking manifestly impracticable questions, or questions to which replies have been recently given in the Journal. The letters of AN AMATEUR, SUNDERLAND, G. K., *and* R. ROMER, *we are reluctantly compelled to leave unnoticed, because one or the other of these conditions has not been observed.*

In answer to G. S. W., *the touchstone is a black stone of a close, fine grain, and in order to ascertain the fineness of gold by its use, it is necessary to have a set of "touch needles," that is, small bars of gold of various degrees of fineness. The piece of gold to be tested being rubbed upon the stone, the streak it leaves is to be compared with the streaks made by the touch-needles which the operator supposes to be nearest the quality of the gold under trial, all the streaks being wetted with water or aquafortis.*—E. CHAPLIN.

F. SIMMONS.—*The chain was introduced in place of the fusee, about* 1665.

APPRENTICE.—*The Horological Institute has nothing to do with the competition. It is simply the offer of a private firm. We cannot enter into the matter.*

R. COVENTRY. — *A full description of Harrison's chronometer is given in Volume I. of the Journal.*

BOARD OF TRADE RETURNS,
AS FAR AS RELATES TO WATCHES AND CLOCKS.

	Month ending 31st December.			Year ending 31st December.		
	1872.	1873.	1874.	1872.	1873.	1874.
WATCHES Value.	£38,924	£43,692	£49,832	£351,150	£407,284	£474,119
CLOCKS. Number.	24,230	36,540	47,014	373,625	403,183	421,098
Value.	£34,155	£44,638	£42,428	£438,110	£425,741	£400,686

CENTRIFUGAL FORCE AND THE COMPENSATION BALANCE.

In the January number of the journal, Mr. Immisch propounds what will be a new theory to most of your readers, on the error of the compensation balance. He says: "It is my belief that the true cause of the errors will be found in the centrifugal force exerted by the balance causing the weights to fly out at the quickest part of the vibration;" and in your last number Mr. Webster is "induced to make a few observations in corroboration of his views." Mr. Webster says: "By actual trial it was found necessary to make the compensation weights approach the centre for equal increments of heat in a greater ratio than they receded from it for equal decrements. . . . this is theoretically and mathematically erroneous, for the weights ought to approach the centre for equal increments of temperature in a lesser ratio than they recede." Mr. Webster founds his hypothesis upon the fact that a one-second pendulum requires to be shortened a less amount than it would have to be lengthened to make an equal difference in the time of its vibration. A little examination, however, will show that this fact is in exact accord with the requirement that the compensation weights should approach the centre of the balance in a greater ratio than they recede, if the controlling power of the balance is to correspond with the force of the spring.

Let us first take the action of the balance. r. Webster states that "the time of vibra- n of the balance varies with the square t of the distance between the centre of ration and the axis of rotation." As an stract statement, this is true—that is, if balance vibrated without any controlling 'er, but as a balance, practically, only ates in connection with a spring, the of vibration will be governed by two ents—the diameter of the balance, and force of the spring. A pendulum, to te in a given time, is always the length in the same latitude, simply e the force of gravity is constant in it; but the compensation balance, l of being always the same diameter to in a given time, has its diameter lly altered during changes of tempera- order to keep the time of its vibra- nstant, because the amount of the g force, that is, the strength of the pring, varies.

be admitted that the force of the pring varies in the same ratio as the temperature, and that the controlling power of the balance varies as the square of its velocity, and, therefore, as the square of its diameter; then—

Let the strength of spring be $= 10$, and the diameter of balance $= 10$, the controlling power of the balance will be represented by $10^2 = 100$, that is, the strength of spring will be to efficacy of balance as 10 to 100, or 1 to 10. If now, through an increase of temperature, the strength of spring be reduced to 9, the controlling power of the balance, to correspond, should be reduced to $10 \times 9 = 90$.

Again, let the strength of spring, through a decrease of temperature, be increased to 11, the controlling power of the balance, to correspond, should be $10 \times 11 = 110$. Now, the square root of 90 being 9·486, and the square root of 110 being 10·488, it follows that while the diameter of the balance should have been reduced by ·514 in the second case, it should have been increased by only ·488 in the third case.

We will now consider the action of the pendulum. We have seen that in the chronometer it is the variation in the force of the balance-spring, or the regulating force, that gives rise to our perplexity, and that our endeavour is so to alter the diameter of the balance that its controlling power always corresponds with the force of the spring. With the pendulum the case is exactly reversed. With the controlling power or gravity constant, Mr. Webster truly remarks, that a seconds pendulum requires to be shortened a less amount than it would have to be lengthened, to make an equal difference in the time of vibration. But to make the case of the pendulum analogous to that of the balance, we must suppose the force of gravity to vary also. With the seconds pendulum, of a length equal to 39·15 inches, let the force of gravity be represented by 10. Now, if that force could be decreased to 9, the length of the pendulum to vibrate would be

$$\frac{\sqrt{(39{\cdot}15^2) \times 9}}{10} = 37{\cdot}15.$$

Again, if the force of gravity be increased to 11, the length would be

$$\frac{\sqrt{(39{\cdot}15^2) \times 11}}{10} = 41{\cdot}06\,;$$

or while the length of the pendulum would have to be reduced 2 inches from the standard, to vibrate in the same time with a given

decrement of force, it need only be lengthened 1·91 to keep the time of its vibration constant with an equal increment of force.

I believe I have shown, clearly, that the discordance between the action of the spring and that of the balance would lead us to expect an error in the direction in which it occurs. If, however, the error could not be traced to the cause I have indicated, the centrifugal-force theory would certainly not account for it. The velocity of the balance is so small that the amount of centrifugal force, even with the largest vibration, is really infinitesimal, and the amount of the difference in the long and short arcs (which is really what we have to consider) is so little that its effect on the balance need not be considered. Let us take a balance having a circumference of 4 inches, and with one-half of the rim and the compensation weight attached weighing 40 grains. Reckoning two vibrations a second, the velocity with a turn and a half of vibration would be equal to one foot per second, and the amount of centrifugal force equal to 2·5 grains. With a vibration of three quarters of a turn, giving a velocity of ·5 foot per second, the amount would be ·64 of a grain. The difference between the greatest and least would be equal to 1·86, or say 2 grains at the outside, an amount so small, as before observed, as to be utterly inadequate to bend the arm of the balance with any effect. Besides, it is well known to chronometer springers that in any one temperature the long and short arcs, whatever their range, can be made perfectly equal by the adjustment of the balance-spring alone. The difference in the lengths of the arcs of vibration from other causes being provided for by the isochronism of the balance-spring, it is *the difference of arcs through changes of temperature only* that the centrifugal force theory would apply to.

Mr. Webster makes the rather remarkable statement, that the laminated rims of a compensation balance are springs, and that, obeying the laws of all other springs, they become weaker when heated, and stronger when cold, and that therefore they can offer less resistance to the influence of centrifugal force in heat than in cold. Is not this reviving the doctrine of elastic force in an accelerating ratio? and if true, what then becomes of the Astronomer Royal's table?

The laminated rim of a balance is no more a spring than any other piece of solid metal of the same substance, but on account of its shape and the peculiar action of bending inwards in heat, it would offer more resistance to centrifugal force in a high temperature than when cold had made it straighter, and given it a direction outwards. I am unable at this moment to refer to experiments which I know have been made on this subject; but I am certain that the result showed that such metals as brass and steel were stronger in heat up to a temperature much beyond anything in which chronometers are tried. I have tried experiments with long rods of steel and brass, with weights attached to the ends of each in an oven, but if the weights were the same distance from the point of support, both in cold and heat, I could not find them deflected by increase of temperature; but my means of observation were not sufficiently accurate to enable me to give the result with any confidence.

Perhaps the Astronomer Royal might be induced to make some experiments, and set at rest the question whether the loss of elastic force of the balance-spring means anything other than its elongation by heat.

I will only mention, in conclusion, that there must be some mistake in Mr. Webster's reference to Mr. Kullberg's balance, where he says the rim is double the thickness of the ordinary balance. This description could not apply to the flat-rim balance known as Kullberg's balance, but probably refers to the balance of which you gave a drawing in your January number, and which was given to illustrate the efficacy of the laminated arm, and which, Mr. Kullberg stated, would "almost make him believe that a solid steel rim of the same section would act enough to make this error in extremes almost nil."

Of this I am quite certain—that with an ordinary balance having a steel bar and laminated arm double the ordinary thickness no results whatever could be obtained; it would simply not act, and could not be adjusted for heat and cold.

D. GLASGOW.

20, Myddelton Square.

RAILWAY INSURANCE CHARGES.

Since we drew attention to this subject in the January number of the Journal, so many instances of loss and restriction in the transmission of watches and jewellery have been brought to our notice that from want of space we are unable to publish the communications of our correspondents. Three representative cases may, however, be taken to show the injurious incidence of the Carriers Act upon the watch and jewellery trades. (1.) Where, in an endeavour to do business, parcels of goods have been sent by railway uninsured and lost. Here the

railway companies repudiate their liability, in the absence of proof that the goods were stolen by their servants, and as it would be clearly against their interests to endeavour to bring home the crime to their servants, the matter is dropped. (2.) Where the enormous rate demanded by the railway companies for insurance has been paid by the sender rather than run the risk of loss, although nearly the whole of his profit is swallowed up thereby. (3.) Where an application for goods on approbation is absolutely refused by the manufacturer, because he will neither pay the enormous sum required for the insurance of the whole parcel, on the chance of selling a portion, nor send his wares uninsured with the risk of their being stolen in transmission. We understand that the railway companies sometimes compromise the losses sustained by the large silk houses, rather than lose their custom ; but with the trades we represent no such spirit of sympathy is shown. The companies ruthlessly shield themselves behind the Carriers Act, and if the value of the goods lost can possibly be brought over the £10 line, they fight it out with all their power of wealth. A case of particular hardship, recently reported in the *Bath Journal*, has been brought under our notice. A jeweller of that city sent a locket which he had sold, with some other small articles of jewellery on approbation, by the Great Western Railway. The parcel being lost, the sender applied for compensation, clearly showing that he could replace the whole of the articles for less than £10. But no. The railway company resisted on the ground that the retail price of the articles would be just over the limit ; and the judge, after taking time to consider the point, gave it in favour of the company. All the cases we have cited clearly show the necessity (now recognised by the Government) of reconsidering the privileges of the railway companies under the Carriers Act.

Sir Charles Adderley, Bart., on Tuesday, 23rd February, received at the Board of Trade a deputation of Members of Parliament and representatives of the various trades interested, who waited upon him to solicit the support of her Majesty's Government to the motion of Mr. Jackson, M.P., for a select committee to enquire into the operation of the Carriers Act.

Mr. Morley, M.P., in introducing the deputation, explained the object they had in view, remarking that the Carriers Act was passed upwards of forty years ago, when goods, being sent by carriers' carts, were exposed to much greater danger than at the present time, and under the present condition of things its operation could only be regarded as vexatious and oppressive. The charges for insurance of goods by rail were most excessive, which was exemplified by the fact that a parcel of goods could be insured from Lyons to London for a shilling, whilst the insurance on the same parcel on the railways here would amount to a pound. These excessive charges, he maintained, stood in the way of careful arrangements on the part of the carrying companies, whereas if they were fixed with the responsibility they would in all probability exhibit greater care in the selection of their servants. He was somewhat struck with the truth of the remarks of Lord Redesdale as to the travelling public not being aware of how much they were at the mercy of railway companies, and he thought the observation would apply with equal force to those who sent goods by rail.

Mr. Jones, F.R.G.S., Vice-president of the British Horological Institute, representing the watch trade, spoke of the difficulties of their position in consequence of the high rate of insurance upon railways. As an evidence of this he mentioned an instance in which a railway company had asked £6 for carriage and insurance on a parcel worth £75, which was greater than the freight and insurance to India or Havannah. This burden of insurance, he urged, pressed unduly upon the trade, and was highly detrimental to it.

Sir Chas. Adderley, in reply, thanked the deputation for having brought so important a subject before the Board of Trade, and for the explanations which had been made. He said that they must be aware that the nature of carriage as well as the nature of goods had so changed since 1830, when the Act was passed, that that Act could scarcely be applicable to the present state of things. The deputation had shown many great faults in the existing law, and he was most willing that alterations should be made. Mr. Cave had promised a committee in 1868, but he begged them to recollect that neither he nor Mr. Cave had been in office since that day, and he had no doubt that the Government who were in office had from the pressure of business been unable to find time for the investigation of this important subject. He would feel it his duty, when Mr. Jackson asked for a select committee, to grant the application on the part of the Government ; and he hoped that the committee would be composed so that it might look thoroughly into the matter, in order that it might be dealt with without loss of time.

GOLD AND SILVER TRIAL PLATES.

[The report of the Deputy Master of the Mint for 1873 contains, in the form of a memorandum by Mr. W. Chandler Roberts, the Chemist of the Mint, the following account of ancient trial plates, prepared to ensure the integrity of the gold and silver coinage of this country, and the various steps and incidental difficulties in the production of new plates, both gold and silver, in 1873, after a lapse of 45 years.]

Before proceeding to describe the precautions which have been taken to ensure the purity and accuracy of the new trial plates, I may be permitted to present, in a tabular form, a statement of the results of assays which I have made to ascertain the composition of the ancient trial plates, together with some remarks as to their history. I have to express my thanks to Mr. Prideaux, clerk of the Goldsmiths' Company, for having enabled me to consult the Records relating to the preparation of the plates preserved at Goldsmiths' Hall.

Table showing the Composition of the Ancient Gold Trial Plates of which portions are preserved in the Mint.

Date.	Standard prescribed by law. In carats and grains.	Standard prescribed by law. Decimal equivalent.	Actual Composition.	Remedy or permitted variation in carats and in thousandths.	Remarks.
1349				½ carat or 13·9	Amongst the Cotton Manuscripts is preserved the account of a trial of the pyx of gold nobles in the year 1349. The coins were to be compared with one ounce of florins of Florence, kept in the Treasury as standards.
1477	23 3½	994·8	Gold - 993·5 Silver - 5·15 Copper* 1·35	⅛ carat or 5·2	This, the earliest Trial Plate of which there is any record, was made in the 17th year Edw. IV. Special legal provisions were enacted for the protection of the coin of the realm, which appears to have been debased in every possible way. When gold coins were first introduced into England by Henry III. in 1257 they were 24 cts. fine, that is, pure gold. Edward III. in 1345 was the first to use the standard of this plate, 23 cts. 3½ grs. fine, or 994·8.
1527	22 0	916·6	Gold - 915·5 Silver - 78·3 Copper 6·2	⅙ carat or 6·9.	In 1526 Henry VIII. issued a proclamation directing that crowns of the double rose should be coined of the standard 916·6 for concurrent issue with sovereigns and other coins of the original standard of 994·8. This plate was made in the following year.
Probably 1543	23 0	958·4	Gold - 954·4 Silver - 34·8 Copper 10·8	⅙ carat or 6·9	This plate was probably prepared to correspond with the debasement of standard which took place in this year from 994·8 to 958·4. In 1544 the standard for all gold coins was reduced to 916·6, and again in 1546 to 833·4, the lowest point ever reached in England.

* With Copper are included any minute quantities of other base metals which may be present.

Date.	STANDARD PRESCRIBED BY LAW.		ACTUAL COMPOSITION.	Remedy or permitted variation in carats and in thousandths.	REMARKS.
	In carats and grains.	Decimal equivalent.			
1553	23 3½	994·8	Gold - 990·3 Silver - 9·7 Copper —	⅙ carat or 6·9	This is the first plate bearing an inscription, which runs as follows: STAN° o OF o XXIII o KARE° o X o GRE° o DEMI o FYNE o PRYVE o MARKE o Φ. It bears no date, but the "pryve marke" (a pomegranate) is the same as that borne by the sovereigns and "angels" issued by Mary in this year. In a proclamation, dated 1553, it is stated that the coins shall be made of "fine gold," which doubtless, means the old standard of 994·8, which, according to Ruding, was in use in this year.
1560	22 0	916·6	Gold - 913·7 Silver - 60·8 Copper 25·7	⅙ carat or 6·9	On her accession to the throne in 1558, Elizabeth took active measures to continue the improvements in the standard of the coinage which had been commenced by Edward VI. On the 8th November, 1560 (the year in which these plates were made), an indenture was made with Thomas Stanley to coin gold of both standards.
1560	23 3½	994·8	Gold - 994·3 Silver - 5·7 Copper —	⅛ carat or 5·2	
1593	22 0	916·6	Gold - 915·9 Silver - 52·1 Copper 31·9	⅙ carat or 6·9	In the 35th year of Elizabeth's reign (1593) a commission was granted to Sir R. Martin to issue coins of the standard 916·6; this plate was, doubtless, made with reference to that coinage.
1605	23 3½	994·8	Gold - 990·3 Silver - 8·3 Copper 1·4	⅛ carat or 5·2	In the first two years of his reign (1603-4) James I. issued coins of the standard of the previous plate, namely 916·6. In 1605, however, he raised the standard back to the original 994·8. A plate of the standard 916·6, dated 19th November, 1604, is mentioned in "Pollet's Abstracts of Pyx verdicts," but no portions of it remain in the Mint.
1649	22 0	916·6	Gold - 913·0 Silver - 51·1 Copper 35·9	⅙ carat or 6·9	On the 16th November 1649 (the first year of the Commonwealth) an Act of Parliament was passed empowering the council of state to administer an oath to a jury of goldsmiths charged with the preparation of this plate. It was accordingly made on the 20th December following.
1660	23 3½	994·8	Gold - 990·9 Silver - 3·7 Copper 5·4	⅙ carat or 6·9	Charles II., soon after his accession, ordered these plates to be prepared, rejecting those made under the Commonwealth, which had only been employed at one trial of the pyx. With regard to the 994·8 plate, it may be mentioned that no coins appear to have been issued of this composition after the year 1640. No record of the preparation of these plates is preserved at Goldsmiths' Hall.
1660	22 0	916·6	Gold - 912·9 Silver - 53·3 Copper 33·8	⅙ carat or 6·9	
1688	22 0	916·6	Gold - 914·6 Silver } 85·4 Copper }	⅙ carat or 6·9	

Date.	STANDARD PRESCRIBED BY LAW. In carats and grains.	Decimal equivalent.	ACTUAL COMPOSITION.	Remedy or permitted variation in carats and in thousandths.	REMARKS.
1707	22 0	916·6	Gold - 917·1 Silver - 59 5 Copper 23·4	$\frac{1}{6}$ carat or 6·9	This plate appears only to have been used at the trial of the pyx which took place on the 21st August, 1710. After this it was finally abandoned, probably because it contained too much gold, and was therefore to the disadvantage of the Master. For instance, at the next trial, on the 7th Aug., 1713, the use of the 1660 and 1668 plates was resumed, both of which were considerably below standard.
1728	22 0	916·6	Gold - 916·1 Silver - 50·4 Copper 33·5	$\frac{1}{6}$ carat or 6·9	
1829	22 0	916·6	Gold - 915·3 Silver - 37·6 Copper 46·5	$\frac{1}{16}$ carat or 2·6	It may be observed that in 1817 an effort was made to attain greater accuracy in the coinage, the remedy being in that year reduced from 6·9 to 2·6 parts in a thousand.

NEW TRIAL PLATES.

Date.	In carats and grains.	Decimal equivalent.	Actual Composition.	Remedy.	Remarks.
1873	22 0	916·6	Gold - 916·61 Copper 83·39	2·0	The standard plate was alloyed with copper only, in order that it might correspond with the composition of the British gold coins. Both plates were prepared at the Mint, and verified by the Goldsmiths' Company, 22nd December, 1873.
1873	Supplementary Plate.		Pure Gold.		

TABLE showing the COMPOSITION of the ANCIENT SILVER TRIAL PLATES of which Portions are preserved in the Mint.

Date.	STANDARD PRESCRIBED BY LAW. In ozs. and dwts.	Decimal equivalent.	ACTUAL COMPOSITION.	Remedy or permitted variation in dwts. and in thousandths.	REMARKS
No date.			Silver - 757·4 Copper 246·6		This plate bears no date, nor is it accompanied by any label, but its form would appear to indicate that it belongs to a very early period. Until the year 1842 the trial plates were kept in the Pyx Chapel, in the cloisters of Westminster Abbey, where certain assay pieces of gold and silver, with ancient memoranda relating to them, were also found. One of these pieces is the extremity of a bar or ingot of silver, which has its upper surface rounded, and imperfectly impressed with the dies of a coin of the time of Henry III. (1216-1272). Mr. Black, formerly Assistant Keeper of the Public Records, considered that this had been employed at the trial of the pyx, and that it is probably the remains of the oldest standard piece which has been preserved.

Date.	Standard prescribed by law. In ozs. and dwts.	Standard prescribed by law. Decimal equivalent.	Actual composition.	Remedy or permitted variation in dwts. and in thousandths.	Remarks.
1477	11 2	925·0	Silver. 923·5 Copper 76·5	2 dwts. or 8·4	
Probably 1527			Silver - 885·5 Copper 114·5		These three earlier plates differ in form from all those which succeed them. They are chisel-shaped, the ends being hammered out apparently in order to receive the impression of a coin. This impression is, however, only preserved on the 1477 plate. There is no record of any coinage having the composition of this plate, but a label is attached to it bearing the date "13th October 18th Henry VIII." (1527).
1542	9 6	775·0	Silver - 763·6 Copper 236·4	Probably 3 dwts. or 12·5	Henry VIII. issued in Ireland, in his 33rd year (1542), coins of the standard. Their circulation in England was prohibited, but within four years he reduced the standard in England to 333·3 parts of fine silver in 1,000.
1553	11 2	925·0	Silver - 927·0 Copper 73·0	2 dwts. or 8·4	Mary, on her accession to the throne, issued a proclamation stating that a coinage of "Silver in fineness of the standard sterling" should be commenced; in the indenture, however, of the same date (1553), the composition is fixed at 916·6. This plate, which bears an inscription similar to that on the gold plate, and the same privy mark (a pomegranate) appears to have been prepared to correspond with the composition named in the proclamation, but no plate having the composition prescribed in the indenture (916·6) exists in the Mint. Several coinage arrangements introduced by Mary were convenient. The standard of silver was the same as that of gold, and their values, therefore, were easily comparable. The weights of the coins were so adjusted that a crown in silver, or two sovereigns in gold, weighed one ounce.
1560	11 2	925·0	Silver - 930·2 Copper 69·8	2 dwts. or 8·4	On the 27th September 1560, Elizabeth issued a proclamation, stating that "to make an end of all troubles arising from debased monies, Her Majesty had already begun a coinage of fine money in the Tower of London." This plate probably marks the restoration of the old standard, which took place in this reign. The convenient arrangements introduced by Mary were discontinued, a change which was subsequently regretted by Lord Liverpool, in his letter to George III. (p. 100), as it introduced difficulties in the comparison of the values of gold and silver coin. Had Mary's regulations been allowed to continue, the composition of both gold and silver coins in Great Britain and British India would at the present day have been identical.

Date.	Standard prescribed by law. In ozs. and dwts.	Standard prescribed by law. Decimal equivalent.	Actual Composition.	Remedy or permitted variation in dwts. and in thousandths.	Remarks.
1600	3 0	250·0	Silver - 252·0 Copper 748·0	3 dwts. or 12·5	This plate is labelled "Standard for Ireland, Anno 1600"; and in 1601 Elizabeth decreed that coins of about this standard should be issued in Ireland; or, as the indenture states, "with such provision and moderation as in former times had not been done, and so as none of our Highness' loving and faithful subjects should be thereby prejudiced." Considering how extremely debased this coinage was, it is difficult to understand these expressions. Simon states that the standard was 241·5, but Malynes fixes it at 250, a statement which is confirmed by the composition of this plate.
1601	11 2	925·0	Silver - 925·1 Copper 74·9	2 dwts. or 8·4	This plate was employed at the trials of the pyx up to the 20th June, 1605, and its composition is very closely in accordance with the true standard.
1604	11 2	925·0	Silver - 922·7 Copper 77·3	2 dwts. or 8·4	
1649	11 2	925·0	Silver - 923·7 Copper 76·3	2 dwts. or 8·4	The jury of Goldsmiths empanelled to prepare the gold plate on the 16th November, 1649, were also ordered to make this silver plate of the standard 925, to be used as "Standard Trial Pieces." These pieces were "to be indented and printed according to the pleasure of the Parliament."
1660	11 2	925·0	Silver - 924·2 Copper 75·8	2 dwts. or 8·4	As in the case of the gold plates of this date, there is some uncertainty as to where this plate was prepared.
1688	11 2	925·0	Silver - 922·0 Copper 78·0	2 dwts. or 8·4	
1707	11 2	925·0	Silver - 922·0 Copper 78·0	2 dwts. or 8·4	
1728	11 2	925·0	Silver - 928·9 Copper 71·1	2 dwts. or 8·4	
1829	11 2	925·0	Silver - 925·0 Copper 75·0	1 dwt. or 4·2	Prepared by a jury of Goldsmiths, and verified by the King's Assay Master.

New Trial Plate.

1873	11 2	925·0	Silver - 924·96 Copper 75·04	4·0	Prepared at the Mint, and verified by the Goldsmiths' Company, 22nd December, 1873.
1873	Supplementary Plate.		Pure Silver.		

vident that, although the standards
ss were always prescribed by law,
l plates have nevertheless at times
y inaccurate. The imperfections of
plates are mainly due to sources of
ich had been recognised, but which
ored when the last plates were made;
is well to explain, therefore, that
ere, in former times, authoritatively
ced to be "standard" simply with
to the results of an inaccurate pro-
ssay. The process now consists in
ng an accurately weighed portion of
y to a rapid method of chemical
whereby impurities are eliminated,
precious metal, thus purified, is
eighed, but the method is compli-
d the accuracy of the result may be
by the retention of impurities, or by
l loss of metal during the process.
ight of gold as indicated by the
will, in consequence, not represent
unt originally present in the alloy,
therefore necessary to control the
by assaying, side by side with the
nder examination, "standards" or
eces the composition of which is
As, however, any error in the com-
of these checks will be reflected in
lt of the assay, it is preferable to use
f pure metal corresponding in weight
mount which the alloys to be tested
cipated to contain. Formerly such
f pure metal were not employed, and
amount of silver, varying from
$\frac{1}{1000}$th part of the initial weight of
y piece which remained in association
gold, was consequently reckoned as
the assay report. It follows, there-
t even the more recent plates, when
ly assayed, are usually found to be
below the exact standards which
re intended to represent.
experiments made with a view to
the composition of the newly pre-
tandard gold plate show that the
variation of this plate from the
andard does not exceed $\frac{2}{10000}$th part of
le mass; but the use of even a fairly
standard plate is liable to be
l with error, as the actual amount of
metal in the portion taken for the
iece may exceed or fall short of the
ndard. It follows, therefore, that the
ports on portions of metal tested by
son with this check may indicate the
of too little or too much precious

objections to the use of a standard
late are far greater, as the alloys used
for the silver coinage, in this and in other countries are mechanical mixtures, the molecular arrangements of which are very peculiar, and so far as my experience goes, a plate of the legal standard cannot be prepared of uniform composition.

With regard to the use of pure gold and silver plates, it should be pointed out that, if it were possible to obtain gold and silver of absolute purity, there would be no limits to accuracy in assaying, except such as arise from operations of a purely mechanical nature. Of course, it is not possible to attain to chemical purity, and the presence of traces of impurity in the checks causes the results of assays made in comparison with them to indicate the presence of an amount of pure metal in excess of that actually present in the alloy; but as the converse can never be the case, that is to say, as the gold cannot be more than pure, no danger can arise from this cause, and the error can be easily allowed for.

The supplementary fine gold and silver plates which I have prepared in accordance with my instructions will, I venture to hope, prove eminently satisfactory. I have not been able to prepare, or to obtain from any source, gold of greater purity, even in small quantities. The silver plate leaves little to be desired, although it is not quite as pure as silver prepared by M. Stas, in comparison with which it is as 999·95 to 1000.

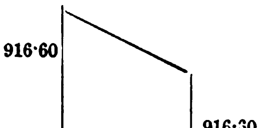
STANDARD GOLD PLATE.

In 1829, when the last gold trial plate was made, the gold coin contained 4 per cent. of silver, and the alloying metal of the plate was a mixture of silver and copper, but improvements in the process of separating gold and silver, which were adopted shortly afterwards by English refiners, rendered it possible to obtain gold nearly free from silver, and since that time copper alone has been used for admixture with the precious metal.

The Coinage Act of 1870 directs that the gold coin shall contain eleven-twelfths of fine gold, but does not specify the metal with which the gold is to be alloyed, and the preparation of the new plate might have been simplified by the use of silver as the alloying metal. After careful consideration, however, I determined to use copper (the purity of which was guaranteed by its high electric conductivity), and thus to preserve identity of composition between the trial plate and the coinage.

Fortunately the gold-copper alloys employed in minting present but slight variations in molecular arrangement, provided the utmost care be taken to ensure a thorough admixture of the constituent metals while in a molten state; but the adoption of copper as the alloying metal greatly increased the difficulty of securing an exact as well as homogeneous plate, and repeated meltings were necessary before the results of assays proved that the bar, into which the alloy was cast, contained the true proportions of gold and copper. This bar was then rolled into a plate, and the results of assays from different parts are shown in the accompanying diagram, from which it will be evident that its composition ranges from 916·5 to 916·7. parts of fine gold in 1000, the mean variation from standard (916·66) being $\frac{1}{25000}$th of the whole mass. I may add that Matthiessen considered the gold-copper alloys to be "solidified solutions of "allotropic modifications of the "metals in each "other," a view which these results tend to confirm, and I am persuaded that the homogeneity of this alloy may now be considered to be clearly established.

New Trial Plate of Standard Gold—weight 72 ounces. (1-10th actual size.)



The composition of different parts of this plate was ascertained by the ordinary parting assay, which is, as I have shown in former Reports, the most accurate and trustworthy method which it is possible to employ.

The actual determination of the proportion of gold and base metal existing in the alloy depends upon the relative accuracy of the initial weight of the portion of metal operated upon, and of the weights used in the final weighing of the purified gold, which gives the result of the assay. In order to avoid errors in this respect, the weights used were from time to time examined and verified by the Warden of the Standards.

In the verification of the plates I had the advantage of the co-operation of Mr. Ridsdale, and, in assuring ourselves of the purity and accuracy of the plates, we made more than a thousand assays.

Standard Silver Plate.

The preparation of the silver trial plate was attended with much difficulty, as the standard silver alloy appears to be a solidified *mechanical mixture* of two solutions, and the cooling of such an alloy is accompanied with a remarkable molecular rearrangement, in virtue of which certain combinations of the constituents of the molten alloy become segregated from the mass, and its homogeneous character is destroyed. In order to explain this, it is necessary to refer to an important series of experiments, conducted in the Mint at Paris by Levol, with a view to ascertain the nature and define the limits of this molecular mobility.

In one experiment the alloy, which contains 900 parts of silver, was cast into a cubical mould of 45 m.m., and a portion cut from the centre of the mass gave on assay 90·95 p. c. of silver, while a portion cut from one of the angles only contained 89·95 p. c., showing a difference of 1·0 p. c. Levol proved that it is only the alloy containing 71·893 p. c. of silver which is absolutely homogeneous. He also finds that, while the alloy containing 71·893 p. c. of silver is homogeneous, in all alloys containing more silver than this amount, the centre of the solidified mass is richer than the exterior; and that, on the other hand, in alloys of fineness lower than 71·893 p. c. the centre contains less silver than the external portions.

I endeavoured to prepare a plate of uniform composition by pouring a thoroughly stirred fluid mass of the silver-copper alloy into open moulds of iron and stone, but the rapid cooling which followed did not arrest the rearrangement of the alloy, which, as the experiments show, accompanies the solidification of the mass. A plate was cast into a mould of porous brick, the mould being maintained at a bright red heat in a separate furnace, in which, when filled with metal, it was allowed to cool slowly. The results of assays prove that the mass was far from homogeneous, although the molecular arrangement differs considerably from that of a similar plate cooled rapidly.

A diagram is given, showing a mass of 112 ounces of the silver-copper alloy thoroughly stirred in a crucible which was then left in

urnace. The surface of the alloy was
d with incandescent charcoal, and the
al extinction of the fire was effected by
g the damper. The results of assays
upon different parts of horizontal
ns of the mass are shown in the
m, and prove that the composition of
ass is not uniform, although there is
cided concentration of silver towards
ntre. The silver has accumulated at
l points which do not appear to bear
lation to the geometrical form of the
I cannot account for this, but it
to illustrate the difficulties with
investigations such as these are beset.
gradual increase in richness from the
to the centre of a strip of standard
is well shown by a curve which gives
sults of 11 assays made on portions of
cut in a line at right angles to the
of an ordinary fillet or strip of silver
ed for the coinage of florins.

m the foregoing remarks it will be
t that it is impossible to cast a
rd silver plate or bar of uniform com-
n, and it was necessary, therefore, to
to an artifice in order to obtain a
rd trial plate of the required dimen-
One thousand ounces of standard
were cast into an iron mould heated
hort of redness, the interior of which
0 c.m. long, 25 c.m. wide, and 5 c.m.
The mass so obtained was placed
the bed of a planing machine, and its
surface to a depth of 4 m.m. was
ed. The remaining metal was then
into a sheet 1·5 m. long, 45 c.m.
and 1·8 m.m. thick.

tions of metal were then taken from
rts of the sheet and assayed, and the
s proved that the silver had concen-
itself in the centre of the mass, and
he portion shown as detached could
be used as a trial plate. The mean of
e assays taken on this portion gave
6 as the composition of the plate,
, therefore, only varies from standard
th part of the whole mass, and I am
ded that the remarkable structure of
loy renders it highly impossible that a
perfect plate could be prepared.

careful examination of the assays on
tire mass of 1000 ounces convinced
at the irregularities of composition
ess than might have been anticipated
he results of the previous experiments;
s the solidification in this case must
een gradual, it appeared advisable to
ain the extent to which the arrange-
of the alloy is affected by slow and
uniform cooling. Levol employed in his researches iron moulds, each provided with a funnel-shaped tube, and he pointed out that this form was necessary in order to avoid irregularities of composition which are caused by the rapid cooling of the surface of a mass of metal cast in an open mould. Their structure confirms Levol's statement as to the concentration of silver towards the centre of the mass, but they also prove that the molecular rearrangement is comparatively slight if the mass of metal is slowly and uniformly solidified. Experiments on a series of silver-copper alloys are now in progress, and I hope to communicate the result in a subsequent report.

Pure Gold Plate.

The preliminary experiments satisfied me that two methods might be tried with advantage in the preparation of the 73 ounces of pure gold required for this plate. I dissolved in each case about 80 ounces of "cornets" of the purest gold which I could obtain in nitro-hydrochloric acid, the excess of acid being driven off by slow evaporation. Platinum and the allied metals were carefully sought for, and the chloride of gold was then dissolved in a large quantity of distilled water, so that each ounce of the former was dissolved in nearly two gallons of the latter. This solution was then allowed to rest for three weeks, when the precipitated chloride of silver was removed by careful filtration.

First method.—I employed pure sulphurous acid as a precipitant, rejecting the portions first and last precipitated, the middle portion being carefully washed with hot hydrochloric acid of sp. gr. 1·1 and afterwards melted with the addition of bisulphate of potash in a Picardy crucible.

Second method.—The process adopted for the preparation of the dilute solution of chloride of gold was the same as that described above, but oxalic acid was employed as the precipitant; the resulting gold, after careful washing, as in the previous case, was melted in a Picardy crucible and cast into a stone mould. The process first described has the merit of being extremely simple, but the gold obtained by it proved to be sensibly less pure than that prepared by means of oxalic acid, as will be seen from the following table, which gives the degrees of purity of gold prepared by different methods.

TABLE showing the DEGREES OF PURITY OF GOLD prepared by different methods.

Process adopted.	Degree of Purity.
Reduction of chloride of gold by means of sulphate of iron. The metal fused in a clay crucible with bisulphate of potash and borax ...	999·85
Reduction of chloride of gold by means of pure sulphurous acid gas. The metal fused as before	999·89
Reduction of chloride of gold by means of oxalic acid. The metal fused as before. Portions were heated to redness in a tube rendered vacuous by means of a Sprengel exhauster, which, however, did not sensibly increase the purity of the metal*	1000·00
Reduction of chloride of gold by means of alcohol	999·89
Electrolysis of cyanide of gold and potassium	999·90

PURE SILVER PLATE.

The method adopted for the preparation of pure silver was that recommended by M. Stas. It depends upon the complete reduction which ammoniacal solutions of silver salts undergo when acted upon by ammoniacal cuprous sulphite, or rather by a mixture of sulphite of ammonia and an ammoniacal salt of copper.

Standard silver was dissolved in dilute boiling nitric acid, and the solution of nitrates of silver and copper thus formed evaporated to dryness, the saline mass being then fused, in order to destroy traces of nitrate of platinum.

On cooling, the nitrates were dissolved in excess of dilute ammonia, the solution being then allowed to stand for 58 hours, after which it was passed through a thick paper filter, distilled water being added, until the weight of silver present was not more than 2 per cent. of that of the whole bulk.

The quantity of sulphite of ammonia necessary for the precipitation of the silver was thoroughly mixed with this argentiferous solution, which was allowed to stand for 48 hours in a closed vessel, and at the end of this time about a third of the silver present had been reduced (in consequence of the cupric becoming a cuprous salt), and was precipitated in the form of very brilliant greyish white crystals. By heating the supernatant liquid to a temperature of about 65° C. for some hours nearly all the remainder of the silver was precipitated. The liquid was decanted, and the silver obtained from the hot and cold solutions were separately washed by decantation with ammoniacal water, until the washings ceased to turn blue on exposure to the air, and to precipitate chloride of barium. The silver was then left for several days in strong ammonia, and finally, after having been thoroughly washed with distilled water, was melted with borax and nitre, and cast into a mould.

In order to assure myself of the purity of this silver, I tested it side by side with silver distilled in vacuo according to the directions of M. Stas in a crucible of lime with the aid of an oxyhydrogen blowpipe, and I also took the precaution of heating it to redness in vacuo, in order to remove traces of occluded gases.

In conclusion, I would offer some remarks as to the practical use of trial plates. They were formerly pattern standards of fineness, by which the fidelity of the work of the Mint Master or goldsmith was tried, but at the present day it would be nearly impossible to issue coins known to be defective in fineness, and the trial plates hitherto in use have certainly afforded a means of determining whether the coins are in accordance with the legal requirements. It must, however, be borne in mind that in most countries the metallurgical operations of minting are now characterised by minute accuracy, and that even the small differences in composition exhibited by different parts of the new standard plates become of serious importance when calculated on amounts of gold and silver coin, such as those issued in 1872, which were 119 and 137 tons respectively. At the same time the new supplementary plates of fine gold and silver constitute standards of reference by which the accuracy of a coinage can be rigorously tested, and will further be of the greatest value to assayers generally, by enabling them to ascertain the purity of the check gold and silver employed in their operations, and thus to avoid the discrepancies which are now often exhibited in assay reports.

W. CHANDLER ROBERTS,
Chemist of the Mint.

* This metal was used for the supplementary trial plate. Its purity, after rolling, proved to be 999·95.

THE COMPENSATION ERROR.

LETTER FROM MR. ARTHUR E. NEVINS TO MR. HARTNUP.

Extracted from the Proceedings of the Royal Astronomical Society.

my last voyage from Liverpool to Calcutta, on board the ship "Tenasserim," I had an ɔortunity, through the kindness of the commander, Captain T. C. Potts, of testing the ıctical value of your method of finding the rate of a Chronometer at sea, by the appliion of corrections due to change of temperature.

In 1873 I obtained a copy of your Report to the Marine Committee of the Mersey cks and Harbour Board, for the preceding year, in which you have given examples of the thod of making the necessary calculations, and I have followed the instructions there 'en. The two Chronometers used on the voyage were named "J. Basnett & Son, . 713," and "Thomas Blundell, No. 209." The data from which I made my calcuions I obtained from two certificates, given by you at the Bidston Observatory, in ɔtember, 1871, from which I obtained the following results :—

No. 209.

Rate in $55° = -5^s{\cdot}58\ r$
„ $70° = -4^s{\cdot}00\ r'$
„ $85° = -2^s{\cdot}70\ r''$

$r - r' = -1^s{\cdot}58 = d$
$r' - r'' = -1^s{\cdot}30 = d'$
$d - d' = -0^s{\cdot}28$
$d + d' = -2^s{\cdot}88$;

$$C = \frac{(2d - d')}{30^2} = \frac{-0{\cdot}56}{900} = -{\cdot}00062$$

$$T - 70 = \frac{d + d'}{C \times 60} = \frac{-2{\cdot}88}{-0{\cdot}0372} = +\ 77{\cdot}4\,;$$

$$T = 70 + 77{\cdot}4 = 147{\cdot}4\,;$$

$$R = r' - (T - 70)\frac{d + d'}{60} = -4{\cdot}00 + 77{\cdot}4 \times {\cdot}048 = -0{\cdot}28.$$

No. 713.

Rate in $55° = -0^s{\cdot}72\ r$
„ $70° = -0^s{\cdot}27\ r'$
„ $85° = -1^s{\cdot}35\ r''$

$r - r' = -0^s{\cdot}45 = d$
$r' - r'' = +1^s{\cdot}08 = d'$
$d - d' = -1^s{\cdot}53$
$d + d' = +0^s{\cdot}63$

$$C = \frac{2(d - d')}{30^2} = \frac{-3{\cdot}06}{900} = -{\cdot}0034\,;$$

$$T - 70 = \frac{d + d'}{C \times 60}\quad \frac{+0.63}{-0{\cdot}204} = -3.1\,;$$

$$T = 70 - 3{\cdot}1 = 66{\cdot}9\,;$$

$$R = r' - (T - 70)\frac{d + d'}{60} = -\ 0{\cdot}27 + 3{\cdot}1 \times {\cdot}0105 = -0{\cdot}24.$$

From the above calculations we have the following results :—

	Mean Daily Rate.					
	In 55°	In 70°	In 85°	C	T	R
	s	s	s		°	
No. 209	—5·58	—4·00	—2·70	·00062	147·4	—0·28
No. 713	—0·72	—0·27	—1·35	·0034	66·9	—0·24

Let N = any number of degrees from T; then the rate at $T \pm N = R + C \times N^2$.

On the arrival of the "Tenasserim" in this port in December, 1873, the errors of both Chronometers were found by the time gun; and on her sailing, on the 21st January, 1874, the errors were again obtained by the same means. The rates were found by dividing the difference of these errors by the number of days which elapsed between these two determinations. The following were the errors and rates as found on January 21st, 1874, by means of the time gun:—

No. 209.	No. 713.
Slow on G.M.T., $0^h\ 1^m\ 11^s{\cdot}0$.	Slow on G.M.T., $0^h\ 31^m\ 2^s{\cdot}0$.
Mean daily rate while in port	Losing $0^s{\cdot}8$.
Losing $1^s{\cdot}2$.	

The temperature to which the Chronometers were exposed while in port was, as nearly as I could ascertain, 55° Fahrenheit; therefore in temperature 55° the rate of No. 209 had, between September, 1871, and January, 1874, altered from losing $5^s{\cdot}6$ to losing $1^s{\cdot}2$, and the rate of No. 713 had changed from losing $0^s{\cdot}7$ to losing $0^s{\cdot}8$. I find from your Report that the two factors, C and T, do not often alter unless the Chronometer is cleaned or repaired (which neither of them have been since September, 1871). I have therefore assumed C and T to have remained constant, and I have altered R in both Chronometers agreeably to the above determinations of the rates while in port. With these data, and following the rules laid down in your Report, I have calculated the following table of rates for every 5° of temperature (from 50°—95°), and using it, I have found the error on Greenwich M.T. of each Chronometer for every fifth day from January 21st until May 31st, 1874.

Table of Rates for every 5° of Temperature.

	50°	55°	60°	65°	70°	75°	80°	85°	90°	95°
	s	s	s	s	s	s	s	s	s	s
No. 209	—1·8	—1·2	—0·6	—0·1	+0·4	+0·9	+1·3	+1·7	+2·1	+2·4
No. 713	—1·3	—0·8	—0·5	—0·4	—0·4	—0·6	—0·9	—1·4	—2·1	—3·0

Captain Potts has been good enough to supply me with simultaneous readings of the faces of the two Chronometers for every day of the voyage. The temperatures given are the means for each preceding five days, obtained from the readings of a Board of Trade Thermometer (which was kept in the Chronometer-room) at 9 a.m. daily.

The results of my calculations, and the observations of Captain Potts, are given in the table below.

On May 26th, 1874, the errors of the Chronometers on Greenwich mean time were found to be—

	No. 209.	No. 713.
	h m s	h m s
By the Calcutta time gun	Fast 0 0 15·5	Slow 0 33 3·5
By calculation from rates corrected for change of temperature	Fast 0 0 19·0	Slow 0 33 12·0
Differences, or errors of longitude, by Chronometer .	0 0 3·5	0 0 8·5

You will see by the table, from the calculations for May 31st, 1874, that by correcting the rates for change of temperature the two Chronometers differed from each other in the G.M.T. shown by them by only *two seconds;* but by using the rates found in Liverpool in 55° temperature they differed from each other to the large amount of *four minutes and fifty-two seconds* of time, or one degree and thirteen minutes of longtitude.

Date, 1874.		Errors on Green. M.T. from calculations with Rates corrected for change of Temperature. No. 209.		No. 713.		Difference between the two Chronometers from Calculation.		Comparison with each other.		Differences of Green. M.T. between the two Chronometers from Rates Corrected for Change of Temp.		Uncorrected for Change of Temp.		Mean Temp. Fahr.
		m	s	m	s	m	s	m	s	m	s	m	s	
Jan.	21	—1	11·0	—31	2·0	29	51·0	29	51·0	0	0·0	0	0·0	
	26	—1	18·0	—31	7·0	29	49·0	29	44·5	0	4·5	0	4·5	53
	31	—1	23·5	—31	10·5	29	47·0	29	44·0	0	3·0	0	3·0	56
Feb.	5	—1	26·0	—31	13·0	29	47·0	29	47·0	0	0·0	0	2·0	61
	10	—1	26·0	—31	15·0	29	49·0	29	53·0	0	4·0	0	10·0	66
	15	—1	21·5	—31	18·0	29	56·5	30	3·0	0	6·5	0	22·0	75
	20	—1	15·0	—31	22·5	30	7·5	30	18·0	0	10·5	0	39·0	80
	25	—1	9·0	—31	26·5	30	17·5	30	33·0	0	15·5	0	56·0	79

ate, 874.	Errors on Green. M.T. from calculations with rates corrected for change of Temperature. No. 209 m s	No. 713. m s	Difference between the two Chronometers from Calculation. m s	Comparison with each other. m s	Differences of Green. M.T. between the two Chronometers from Rates Corrected for Change of Temp. m s	Uncorrected for Change of Temp. m s	Mean Temp. Fahr. °
r. 2	—1 3·5	—31 30·0	30 26·5	30 44·0	0 17·5	1 9·0	77
7	—1 5·5	—31 32·5	30 27·0	30 45·0	0 18·0	1 12·0	62
12	—1 9·0	—31 35·0	30 26·0	30 46·5	0 20·5	1 15·5	59
17	—1 11·5	—31 37·5	30 26·0	30 47·5	0 21·5	1 18·5	61
22	—1 17·5	—31 41·5	30 24·0	30 43·0	0 19·0	1 16·0	55
27	—1 19·5	—31 44·0	30 24·5	30 41·5	0 17·0	1 17·5	62
ril 1	—1 18·0	—31 46·0	30 28·0	30 45·0	0 17·0	1 22·0	69
6	—1 11·5	—31 50·5	30 39·0	30 55·0	0 16·0	1 34·0	80
11	—1 3·0	—31 57·5	30 54·5	31 7·5	0 13·0	1 48·5	85
16	—0 55·0	—32 4·0	31 9·0	31 22·0	0 13·0	2 5·0	84
21	—0 47·0	—32 10·5	31 23·5	31 35·5	0 12·0	2 20·0	84
26	—0 38·0	—32 18·0	31 40·0	31 52·0	0 12·0	2 39·0	86
y 1	—0 29·5	—32 25·0	31 55·5	32 8·5	0 13·0	2 57·5	85
6	—0 20·5	—32 32·5	32 12·0	32 24·5	0 12·5	3 15·5	86
11	—0 12·5	—32 39·0	32 26·5	32 41·5	0 15·0	3 34·5	84
16	—0 3·0	—32 48·0	32 45·0	32 58·5	0 13·5	3 53·5	88
21	+0 8·0	—33 0·0	33 8·0	33 18·0	0 10·0	4 15.0	92
26	+0 19·0	—33 12·0	33 31·0	33 36·0	0 5·0	4 35·0	92
31	+0 28·5	—33 21·0	33 49·5	33 51·5	0 2·0	4 52·5	88

the above pages—
n + is used to signify that the error of the chronometer is *fast* on G.M.T.
— " " " " " " *slow* "

Letters to the Editor.

Letters to be addressed to the Editor, at the Institute, 35, Northampton Square, E.C.

THE COMPENSATION ERROR.

SIR,—It appears from the last two numbers the HOROLOGICAL JOURNAL that Mr. ımisch and Mr. Webster attribute the im- rfection in the compensation to centrifugal ce, and as that explanation does not agree th the explanation in my essay on com- nsation balances, I beg leave to make a r more observations.

Mr. Dent once made an experiment with a ronometer to which he applied a balance de of glass, which gave the following ults :—

Temp.	Vibrations per hour.
32°	3606
66°	3598·5
100°	3590

If, therefore, the chronometer had been justed to mean time in freezing, or made 00 vibrations, it would, by the first rise in mperature of 34°, have lost 7·5 seconds, and the second rise 8·5 seconds per hour. is would make a difference of 24 seconds r day; and as a disc of glass could neither be influenced by resistance in rims nor through centrifugal force, it is evident the difference was caused by the balance-spring. It is unknown to me by what instrument the Astronomer Royal found out that balance-springs lose strength in a regular ratio by regular increase in heat, but supposing the Astronomer Royal's and Mr. Dent's experiments were made with similar instruments, and with equal care, one chronometer must have had a better balance-spring than the other. I have adjusted some chronometers with ordinary compensation balances that only went 2 seconds per day slower in 32° and in 100° than in 66°, and others with balances that looked exactly similar in which the difference amounted to 5 seconds per day. I can therefore come to no other conclusion than that balance-springs warp or expand more or less by increase in heat—that this causes an additional friction on the balance-pivots, and retards the vibrations, and as the spring has to overcome this additional friction, it loses rotary strength in an increasing ratio. I cannot agree with Mr. Webster that the balance of a chronometer follows the same law as the pendulum of a clock. If we suspend a light stick by a piece of wire, fastened right angular to its middle, and place on the stick two weights as heavy as it will carry, we then find where we

give it a rotary motion, and make the wire of such a length that the stick vibrates half-seconds when the weights are placed halfway between the middle and the ends ; it vibrates seconds when placed on the ends, which clearly proves that the velocity with which a balance vibrates is in the direct proportion to the distance of the centre of gyration from the centre of motion, and not as the square of the distance.

I am, Sir, yours, &c.,
F. KNUDSEN.

Sir,—Mr. Webster, in his letter this month, states the times of vibration of the balance are as the square roots of the distance of the centre of gyration from the axis, but he does not say anything about the force, or how it is to act. Is it to be the same force applied at the respective centres of gyration of each balance ? or is it to be the same force, acting always at the same distance from the axis ? Or if otherwise, would he have the kindness to explain it, so as to make the subject complete.

Respectfully yours,
JOHN MACKEN.

15, Clarence Street, Feb. 15th.

FLAT-RIM BALANCES.

Sir,—Mr. Knudsen, in answer to an article on the Gradual Improvement in the Rates of Chronometers, published in the Horological Journal (April, 1874), said that the chronometer that had the highest place at the Greenwich trials, 1870, had no auxiliary to the compensation, but that an improved compensation was obtained by giving the balance such a form that the compensation rims were more than double the usual length. By a due attention to length and thickness of rims, Mr. Knudsen says, auxiliaries became unnecessary. This explanation, without any further knowledge of the new balance, very much surprised me, but since the readers of the Journal have now been favoured with a description of the before-mentioned balance, I can account for the success, as well as the reason why a description was not given—because it could only be called a double rim, or flat-rim balance (see my description of similar balances, Greenwich List, 1862). Various balances on the same principle were exhibited by me in the International Exhibition the same year (see *Practical Mechanic's Journal*, Record of the Great Exhibition, 1862). The balance invented by Mr. Knudsen (if I am rightly informed) and exhibited close by, in the same exhibition, had an ordinary upright rim, and additional reverse laminæ, acting in the opposite direction, in order to get the compensating weights at the extreme end of the rim. Being fully convinced that Mr. Knudsen would be the last man wilfully to deprive me of the small credit that attaches to the invention of the double or flat-rim balance, I trust you will insert this in your Journal.

I am, Sir, &c.,
V. KULLBERG.

P.S.—Whilst I am about balances, permit me to correct an error in the report of a discussion held at the Institute, and published in the last January number of the Journal, I was, in that report, inadvertently made to say, the lower the weights are placed on the flat rim, the better. I said, the lower the weights are placed, the more effective will they be in extremes of temperature.

To Correspondents.

We are compelled to withhold the letter of Horologist *penned in a spirit of animosity to Mr. Grossmann. It is too personal and intemperate for publication.*

Will any of your correspondents oblige by giving the necessary instructions of procedure with Geneva jewel-settings when they have become damaged?—Jobber.

Railway Insurance Charges.—At the sitting of the House of Commons, on February 23rd, Mr. Jackson rose to move for a select committee to inquire into the operation of the Act 2nd George IV. and 1st William IV., c. 68 (commonly known as the General Carriers Act, 1830). He complained that the Act did not work well and fairly, and that the high rate of insurance charged by carrying companies was almost prohibitory, so far as regarded the transmission of ribbons, watches, and many other articles which were sent from the places of manufacture to different parts of the country, and expressed a hope that the Government would consent to the appointment of a committee to inquire into the grievances complained of, with the view of providing some remedy.

Sir C. Adderley said that the great changes which had of recent years taken place in the mode of carriage throughout the country had rendered some change in the law necessary, and he therefore consented to the motion.

After a few words from Mr. S. Hill, the motion was agreed to.

THE OPERATIVE DEPARTMENT OF THE MINT.

BY MR. ROBERT A. HILL,
Superintendent of the Operative Department.

(From the Report of C. W. Freemantle, Esq.)

Melting House.

During the past year the work has been of a lighter character than in 1872. The large gold coinage which commenced in 1871 was brought to a close in the month of June, 1873, and the weight of gold melted during the six months from January to June was 2,028,280 ounces, as against 11,002,512 ounces in the year 1872. The amount of gold melted, therefore, during the year was considerably below the average.

Advantage was taken of the stoppage of coining operations for a period of twelve weeks in the months of July, August, and September, to submit to mechanical treatment the whole of the gold "sweep" which had accumulated, and which amounted in weight to 26½ tons. The gold recovered was refined and brought to account, and the "sweep," which was afterwards dried and sold, realized £2,414 10s. This result shows that, notwithstanding the use, for the first time in this department, of mechanical means for the purpose, it is impossible to recover from "sweep" every particle of the precious metal. Arrangements have now been made for the daily treatment of the "sweep" in the melting house, and the necessity of any large accumulation of residues is thus avoided.

Although the amount of silver melted in 1873 was not quite so large as in 1872, it was greatly above the average, 6,369,133 ounces having been melted and cast into bars for the different denominations of coin. Towards the end of the year I was enabled to have a set of moulds finished for half-crown and florin bars, of the reduced thickness mentioned in my memoranda for the years 1871 and 1872, and, as far as the melting house is concerned, these new moulds have been perfectly successful, the metal being as easily cast in them as in those of the original size. A somewhat longer time is occupied in filling them, but their advantages more than compensate for any delay in the operation of pouring. The shilling, sixpenny, and threepenny moulds will now in turn be reduced in thickness, so that it is hoped that by the end of the present year the use of thick bars will have been entirely discontinued.

Owing to the length of time occupied by the treatment of the gold "sweep," the "sweep" from the large coinage of silver which has been in progress since the year 1871 has not yet been dealt with, but steps have been taken to recover the metal contained in it by continuing the usual mode of treatment whenever opportunity has offered, and advantage will be taken of any suspension of the coinage to bring the necessary operations to a conclusion.

The amount of bronze melted was only 45 tons, consisting entirely of the "scissel" from the bars bought for coinage, which were of the required dimensions for rolling when originally delivered to the Mint, and consequently were not subjected to any preliminary operation of melting in this department.

Coining Department.

The rolling machinery is, as is well known, totally inadequate to the requirements of the department, and, from its want of power, has, as in former years, caused much delay in the rapid out-turn of work. The machinery in the rolling-room has frequently to be kept in motion for several hours after the work in the other rooms of the department has been finished, in order that a sufficient supply of "fillets" may be furnished to the adjusting and cutting room, in which the next operation of coining is performed. Another very important objection to the present deficient rolling power is that two different metals cannot be worked at the same time, although

it is frequently desirable that this should be done; and, speaking from experience, I can confidently say that the requirements of the coinage can only be adequately met by doubling the rolling power of the Mint.

A considerable weight of the thin bars above mentioned, the introduction of which has been the means of effecting a saving of much time and labour, was put into work towards the end of the year. A great advantage in connection with these bars is, that it has become possible to dispense altogether with the process of annealing, which in the case of thick bars is indispensable, and thus to obtain greater regularity in the "fillet."

The work in the adjusting and cutting rooms has been most satisfactorily performed the weight of the gold coinage of £24,500,000, which was finished in June last, having been found to be within two-thousandth parts of an ounce of the actual standard weight prescribed by law, while that of the coinage of £6,500,000, finished in 1871, was found to be the exact standard weight. These results show the greatest care and attention on the part of those engaged in this department.

During the suspension of the coinage in the summer, the working gear of the draw-bench was renewed, as suggested in my memorandum for 1872, and it is estimated that the amount of rejected coin has in consequence been diminished by nearly one-third.

The "waste" on the gold coinage only amounted to £57 on each million coined, and considering the pressure upon the operative department during the progress of the coinage, and the rate at which it was necessary that the coin should be produced, this result must be considered very satisfactory. It is unnecessary to point out that the very small "remedy" on the weight of each individual piece allowed by the Coinage Act of 1870, and the consequent increase in the amount of rejected coin, added to the difficulty of working with antiquated and cumbrous machinery, offer serious obstacles to the economical execution of the coinage, and that the above result reflects credit on both the officers and men employed in the department.

In the annealing room experiments have been made with a view to discontinue the practice of "blanching" silver "blanks," and coins of some denominations have been struck and issued without undergoing this process. The loss in this department has in these cases been greatly reduced, and the saving of time and labour incidental to the change of practice is considerable. The experiments will be continued, and it is hoped that their final result will be not less satisfactory.

Die Department.

Owing to the bad quality of the steel supplied for dies, referred to in my memorandum for 1872, the work in this department has been almost doubled; and it has been necessary, in order that the proper supply of dies might be daily furnished to the press room, to employ the artificers "overtime" throughout the greater part of the year.

I append the usual statement, showing the number and denominations of pieces of the Imperial coinage struck during the years 1871, 1872, and 1873, from which it will be seen that in 1873 no less than 5,163 dies were used to produce 43,724,951 coins, while in 1872 only 3,655 were used to produce 59,452,174. Towards the end of the year, however, I succeeded in obtaining some steel of a greatly improved quality, and the dies made from it have produced a far larger proportion of coins than has been obtained from any steel used of late years. A great improvement has been effected in the turning of the dies, by shortening the length of the neck, and consequently giving greater strength to the die. This change materially reduces the number of dies used in the press room, especially when, as has been the case since October, owing to the number of threepences required for shipment to the Gold Coast, the Mint is employed in coining small moneys. The dies now in use produce over seventy thousand pieces per pair, which so far shows a considerable improvement on the results obtained in 1873.

Besides the 5,598 dies used for the Imperial coinage, this department has sunk 526 colonial and other dies, and 4 medal dies; and the total number of matrices, punches, and dies sunk and finished during the year 1873, therefore, has been 6,128. Of

the above-mentioned 718 were worn dies re-sunk, and again finished for coining. The department has also produced during the year 2,000 war medals for the Army and Navy, the usual medals for the University of London, and the gold and silver medals presented by the Foreign Office as rewards of cases of shipwreck abroad.

The total expenditure in wages, including overtime, during the year has been £980 17s. 3d., while the amount earned by extra work performed during the same period was £390 11s. 6d.

MACHINERY DEPARTMENT.

This department has been enabled to meet all demands made upon it for the ordinary appliances required in the processes of coining during the past year, and in June last the operations of the coinage were suspended for a period of twelve weeks, in order that the repairs of the machinery, rendered necessary by the strain to which it had of late years been subjected, might be satisfactorily executed. The renewal of the working gear of the draw-bench and the re-gearing of some of the wheels in the rolling-room were entrusted to private firms, as the time at the disposal of the Mint was limited; but with these exceptions the whole of the necessary repairs were executed by the staff of artificers attached to the department. The 40-h.p. engine was put into thorough repair, and a new condenser and air-pump fitted and fixed. The valve slides of this engine were also re-planed and surfaced, the first motion wheel repaired, and the defective boiler pipes replaced. The 20-h.p. and 6-h.p. engines were similarly examined and repaired, the rollers were renewed and adjusted where necessary, and the eight screw coining presses, with the machinery connected with them, were also thoroughly examined and put into good working order. I should further mention that two entire sets of new moulds for half-crown and florin bars were completed before the close of the year.

I have continued to receive zealous assistance from both officers and men in the operative department, and I have again to express my satisfaction at the manner in which the work of the department has been performed.

DEATH OF MR. J. G. ULRICH.

Some of his early Contrivances for Compensation.

WE have to record the death, at the age of eighty, of Mr. J. G. Ulrich, an old contributor to this journal. Mr. Ulrich may be said to have devoted his life to investigating the causes of the temperature error of chronometers, and devising means for counteracting it. Although his peculiar temperament, no doubt, acted to his prejudice, and served to alienate many of his friends, his unvarying application, through more than fifty years, to the task he had set himself, must be viewed with admiration and respect.

Mr. Ulrich's Essay on Compensation, published in the December and January numbers of the journal, included, as some of his earlier efforts, the diagrams given below, which were held over to allow of his writing a description of them—a labour he was destined never to accomplish. An examination suggests that in Fig. 1, *a* is a platform,

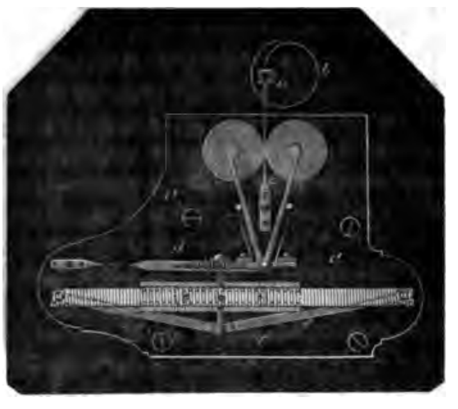


Fig. 1. (Invented between 1823 and 1824.)

on which the Compensation contrivance is fixed; *b* is the pendulum spring; *cc* an elastic spring stud; *dd* is a brass beam, to whose extremities are jointed two steel arms, *ee*, which have a third or middle joint at *f*. When the brass beam expands in heat, it draws the steel bar towards the brass beam, thereby causing the armature, *g*, which is linked to *ee* at *f*, and which carries the friction rollers with their bearings and springs, to move up and down the elastic spring stud, thereby producing a sort of compensation.

Another drawing (Fig. 2), in which the reference letters are not identical with the

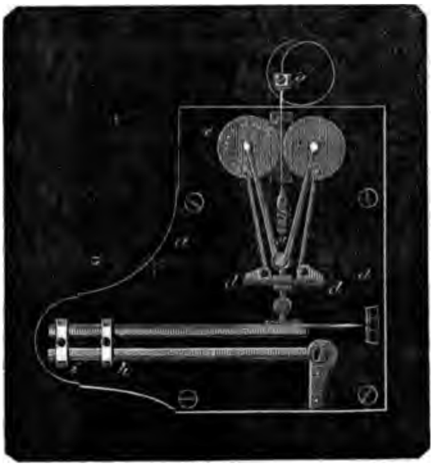


Fig. 2.

preceding, shows substantially the same contrivance, but with a laminæ arrangement

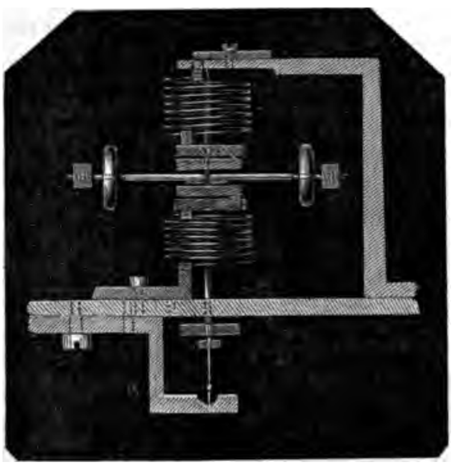


Fig. 3.

instead of the beams. How Mr. Ulrich proposed to get his friction rollers to move

Fig. 4.

parallel with the spring stud, we are not aware, unless the slight plate under the spring serves the purpose of a guide.

In another arrangement, shown by Figs. 3 and 4, he evidently intended using a plain balance, as in the other contrivances; but here he uses two pendulum springs instead of one. The lengthening of one spring, it seems, is intended to oppose the lengthening of the other; and to increase this opposition between the two springs, he has designed compensating collets acting one against the other. This is only a supposition.

We have given these proposals of Mr. Ulrich, not, of course, as practicable ideas, but as a record of what has been attempted in this direction, and as exemplifying the amount of thought and ingenuity he must have brought to bear on the subject.

READY METHOD OF MAKING A LEFT-HANDED SCREW-PLATE.

(From the *Revue Chronométrique.*)

TAKE a small steel plate, as shown in Fig. 1, drill and tap it the size required with an ordinary right-handed tap of the required pitch; then cut through one side of the

Fig. 1.

Fig. 2.

plate as represented, and bend it in the manner indicated by Fig. 2, so that the angle of the threads is just reversed. After hardening, it is evident this plate will enable one to cut left-handed screw.

CLOCK AND WATCH MAKERS' ASYLUM.

A SPECIAL general meeting of the subscribers will be held at the Crown and Woolpack, St. John Street Road, E.C., on Monday, April 19, at seven o'clock, to receive the last year's accounts, and for the purpose of electing one male and one female inmate. For the two vacancies there are two male and three female candidates. George Philcox, chronometer maker; George Smith, enameller; Mary Hussey, widow of jobber and finisher; Elizabeth Brittain, widow of finisher; Rosetta Cox, widow of watch and chronometer jeweller. We are glad to observe from the report of the committee that the treasurer of the institution has a substantial balance in hand.

ON AN IMPROVED METHOD OF CONSTRUCTING THE DEAD-ESCAPEMENT FOR CLOCKS.

By BENJAMIN LEWIS VULLIAMY.

(*Continued from page* 182, Vol. XVI.)

To illustrate this further, suppose A B C, Fig. 1, Plate IV., a scape-wheel of six teeth,

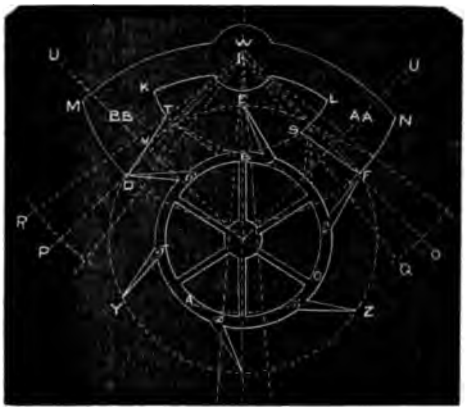


Fig. 1, Plate IV.

to which it is required to apply a pair of dead-beat pallets, which are to take over two teeth, or, what is the same thing, occupy the portion of the circle contained between three teeth*; circumscribe the points of the teeth of the wheel by a supposed circle, Y E Z, divide each of the spaces, D E and E F, between the teeth, D E and F, into two equal parts at G and H, draw the straight lines, D G and F H, and prolong them until they meet at I; the point, I, will be the proper centre of motion for the pallets; from the centre, I, draw the two portions of circles, K L, and M N, intersecting the circumscribing circle at the points, D G and H F, the circular rests of the pallets will be a portion of these circles; the inner rest of the smaller, the outer rest of the larger circle. To determine the angle of lead of the pallets, prolong the two lines, I H F and IGD, to O and P, and from the point I, draw the two straight lines, I Q and I R, forming the two angles, O I Q and R I P, equal to one another; and from the points, F and S, of intersection of the sides of the angles by the portions of circles, K L and M N, in the one angle, and the points, D and T, in the other; draw the straight lines, F S and D T, these will be the inclined planes or faces of the pallets.

As this mode of proceeding would be very difficult, not to say impossible, in practice, except in the case of large wheels, on account of the little distance the points that determine the thickness of each pallet are from each other, the preferable mode is, after having determined the place of the pallets upon the circumference of the wheel, as above described, to draw from the centre, X, of the wheel, Fig. 1, Plate IV., the two lines, X U and X U, bisecting the arcs, F H and D G, which mark the thickness of the pallets; and from the points, V and V, where those lines intersect the circle, to raise the two perpendiculars, V W and V W, which lines will be tangents to the circle; and that done, to draw the lines, F H I and D G I, parallel to the two lines, V W and V W, and the point, I, where they meet, will be the centre of motion of the pallets, and must be the same originally formed; for a chord will always be parallel to a tangent touching the same circle, when the tangent touches the circle at a point equidistant between the two points where the chord meets the circle; and that is the case here, for, by the construction of the figure, the angle, X V W, is a right

* It may be worth while to notice, as a general rule, that a pair of pallets always occupy the space or portion of the circle contained between the number of the teeth they take over and one more; thus, taking over two teeth, they require the space contained between three teeth; were they to take over ten teeth, they would occupy the space contained between eleven. The reason is evident: in the one case, the thickness of the pallets is without the teeth, and the other within, and the thickness of each pallet being equal to half a space, the thickness of the two together must be equal to one entire space; no allowance, as before observed, being made for dross.

angle, and the angles, V X F and V X H, equal angles. The chord, H F, being parallel to the tangent, V W, it follows that the line, O I, which is the chord, H F, prolonged, must be parallel to the same tangent, V W. A similar demonstration will apply to the chord, D G.

That there is but one proper place for the centre of motion of the pallets, and that it is the point found as above described, will be evident, when it is considered that, for the pendulum to be led an equal quantity by the action of the wheel on each pallet (the inclined planes of which must be of equal length, otherwise the action will not be the same on both), it is requisite, making no allowance for drop, that, at the instant the wheel has advanced a quantity equal to half the space between two of its teeth, the lead of the pallet should be completed, and that the tooth, which has just led the pallet to the extremity of the angle of lead of the pallet, should quit the pallet; and, at the same instant, the other pallet should present itself in such a situation that another tooth of the wheel may come into action with it; that when that tooth shall have advanced the same quantity as the preceding, that it shall also have led the other pallet, which it has acted upon to the extremity of its action of lead; and have brought the first-mentioned pallet into a situation to receive the following tooth of the wheel to that by which it was previously led.

This can only be the case when the lines, I O and I P, which pass through the circumscribing circle, intersect it as the points which determine the thickness of the pallets, which, from the construction, it is evident in this case they do. By reference to the figure it will be seen that, in consequence of the angles, O I Q and P I R, being equal to one another, and the sides, I O and I P, of the same angles intersecting the circumference of the circle at the points, H F and G D (equidistant each to each from the point, I), where the circle forming the circular rests intersect the circle circumscribing the points of the teeth of the wheel, the pendulum is led a quantity equal to each of those angles at each vibration. For, supposing the wheel advancing at the moment the tooth, 2, has reached the extremity of the inclined plane of the pallet, A A, the point, S, of the pallet will have reached the point, H, and the point, T, of the pallet, B B, will have reached the point, G, ready to receive the tooth, 1, which at that instant will drop upon it; and when, by the action of the tooth, 1, upon the pallet, B B, it is returned to its former place, the point, F, of the pallet, A A, will be ready to receive the tooth, 3, which will at that instant drop upon it.

To render the above demonstration as apparent as possible, the wheel has been drawn with only six teeth, because, supposing a wheel, even of the size of the wheel in the figure with thirty teeth (the number for a second pendulum), in which case the pallet would be only one-fifth of their present thickness, the portion of the circle the chord would subtend would be so short, and, consequently, the space between the chord prolonged, and the tangent so small, that the distance between the points, I and W, would be much less apparent. In the case of a scape-wheel of the size usually employed in second pendulum clocks, in laying down the lines for the purpose of determining the distance between the two centres, it will be sufficient, unless when very great accuracy is required, to draw two lines, bisecting the points which mark the thickness of the pallets upon the circle of the wheel, and upon those lines, at the points where they intersect the circle of the wheel, to raise two perpendiculars, and to take the point where these perpendiculars meet, as the centre of motion of the pallets.

Were the centre of motion of the pallet placed higher or lower than the proper place, as above determined (see Figs. 2 and 3, Plate IV.), in both which the angle of lead is drawn the same as in Fig. 1. In the one case, the action of the tooth of the wheel upon the inclined plane of the pallet, A A, (see Fig. 2)—here the centre of motion of the pallets is raised—would lead the pendulum an angle less than the angle of lead, O I Q, as drawn, by a quantity equal to the angle, O I X, and, consequently, the point, T, of the line, T D, or inclined plane of the pallet,

B B, instead of having advanced a sufficient quantity to meet the tooth, 1, at the point, G, will only have advanced to H, and the point of the tooth, 1, would drop upon the

Fig. 2, Plate IV.

inclined plane, H K, of the pallet between P and P ; and the pallet advancing with less rapidity than the wheel, they will meet nearer P than H.*

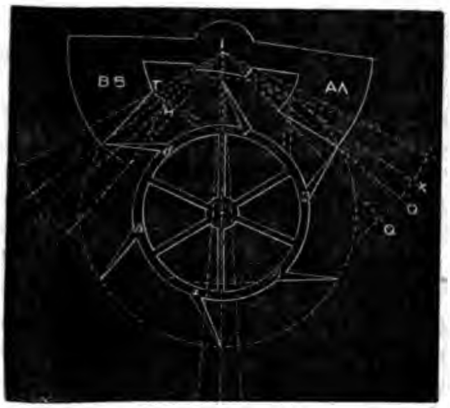


Fig. 3, Plate IV.

In the other case (the centre of motion of the pallets is dropped nearer to the centre of the wheel) the action of the wheel upon the inclined plane of the pallet A A, Fig. 3, Plate IV., would lead the pendulum an angle exceeding the angle O I Q of lead already drawn, by a quantity equal to the angle, I O X, and consequently the pallet B B will be led so much too deep into the wheel, that the point of the tooth, 1, instead of dropping safely upon the pallet, will drop upon its circular rest at a very considerable distance from the point H.*

It would be impossible for any clock to go with the pallets shaped as drawn, Fig. 2 and 3, Plate IV. ; but it does not follow that pallets could not be made, preserving the same centres of motion, which would perform; and at first sight, and upon a small scale, appear as mathematically correct as the escapement drawn Fig. 1, Plate IV.

(*To be continued.*)

In 1663, Martinelli, of Spoleto, wrote a curious work, describing various methods of constructing what he calls elementary clocks, that is, clocks which were set going by earth, air, fire, and water ; some of which could be made to show the time of day, the days of the week and month, and the courses of the moon and planets, with the epact. Time was measured in the water-clocks by suffering that element to pass successively through the compartments of a drum-shaped cylinder, acting as a pulley to a cord with a counter-weight, the rapidity of the motion being determined by the quantity of the water, or the bore of the orifice through which it escaped. The motion of the earth or sand clock, was regulated in a similar manner. In the air-clock time was measured by the pumping of a bellows, like those of an organ, the gradual escape of the air regulating the descent of a weight, which carried round the wheels, as in other time-keepers. In the fire-clock the motion was produced upon the principle of a modern smoke-jack, the wheels being moved by means of a lamp, which also gave light to the dial ; and the clock could be made to announce the several hours by placing at each corresponding number of crackers, which by certain contrivances were exploded at proper times. He tells us that these clocks offered considerable advantages to persons troubled with insomnia, or want of sleep, as they gave a soft light, and, without noise, marked the silent flight of time.

* The effect that would result in practice from the tooth dropping on the inclined plane of the pallet would be to cause the scape-wheel, and, consequently, the whole train of wheels, to recoil,—an evil subversive of the principle of the escapement.

* The effect produced by the tooth taking more hold on the circular rest than is absolutely necessary for safety is to considerably increase the friction on the rest. In practice the tooth should drop just on the circular rest, and no more.

INTERNATIONAL EXHIBITION OF MARITIME & RIVER INDUSTRIES IN PARIS.

The first Exhibition of this kind in Paris will be open at the Palace of Industry from the 10th of July until the 15th of November in this year, under the management of a committee of note, assisted by foreign commissioners. Chronometrique, and other instruments of precision connected with the navy, will be an important feature of the exhibition, and all applications for space to exhibit, and other inquiries connected with this section, should be made to M. A. H. Rodanet, to whose letter, published in this number of the Journal, we direct the attention of our readers. According to the prospectus before us, Class XV. is devoted to *Nautical and Optical Instruments, Chronometry, Marine Telegraphy, Charts:* comprising chronometers, mariners' compasses, barometers, thermometers, sextants, octants, logs, leads and sounding-lines, sand-glasses, loxodographs, wind-vanes, hygrometers, electric bells and signals, detonating bombs and fusees, charts for navigation and fishing. Class XVI. also includes horological mechanism, watchwork, electric clocks, sand-glasses, &c. Table space to exhibit will be charged at the rate of £1 per metre for the whole period of the Exhibition, and wall space at 8*s*. per metre, exhibits upon which must not exceed three metres in height. Glass cases and other requirements must be furnished by exhibitors, or at their cost by the commission. The following are exempt from charge for exhibiting:—Ministers of governments, French and foreign museums, officers of French and foreign navies, French and foreign chambers of commerce. Exhibitors of paintings, or of purely artistic productions, or of articles of an exceptional and scientific value, would also be absolved from charge. All exhibits must be removed by the 30th of November, or, in default, would be removed to a repository, and, if unclaimed by the 30th of May following, would be sold by auction.

A watch of Cromwell, now in the British Museum, was bequeathed to the nation in 1748 by Sir Robert Rich, bart.

WATCH-GLASSES.

Watch-Glasses were formerly made in England by workmen who purchased from the glass-house globes of five or six inches in diameter, out of which by means of a piece of red hot tobacco-pipe, guided round a pattern watch-glass placed on the globe, they cracked five others; these were afterwards ground and smoothed on the edges. In the Tyrol the rough watch-glasses are supplied at once from the glass-house; the workman applying a thick ring of cold glass to each globe as soon as it is blown causes a piece of the size of a watch-glass to be cracked out. The remaining portion of the globe is immediately broken and returned to the melting-pot. Formerly this process could not be adopted in England with the same economy, because the whole of the glass taken out of the pot was subject to excise duty. In England, at the present time, the crown glass, used for enclosing the dials of clocks and watches, before being moulded or bent into the required form, is first cut into circular shape by means of a circle-cutter, which consists of a circular board, covered with wash-leather, which is made to revolve on a pivot by one hand of the operator, while with the other hand he presses down a diamond on to the glass. The diamond is fixed at the end of an adjustable arm, which traverses a slot, the exact diameter of the circular plate to be cut being regulated by an index fixed at the side of the slot. The circular flat plates, which are removed to moulds turned out of solid firestone, the sinking of the moulds being of flat elliptical section, are put into one or other of the furnaces, according to the size of the glass to be bent; while in the furnace, the mould is kept in continual circular motion by the long iron rod of the operator, until the glass sinks into the required form. The grinding and polishing the edge of the glass is the next operation By a simple and ingenious contrivance the edges of clock and watch-glasses are ground. The operator stands in front of the work, with his right hand turning round a handle, placed vertically above the bench, and with his left hand holding a sort of hood, or cup supplied with emery powder, by which the

grinding is partially effected; the glass to be ground is temporarily fixed on a boxwood nallet, by means of cement, at the top of a ipindle, which passes through the bench, and o which rapid motion is communicated by a ound band from a horizontal wheel below he bench, turned by the right hand of the perator. After the grinding is completed, he edge of the glass is smoothed with umice-stone, and finally polished with oxide f tin, usually called putty-powder.—*Wood's Curiosities of Clocks and Watches.*

CLOCK-MAKING IN THE BLACK FOREST.

Clock-making in the Black Forest is at the present time chiefly confined to Dittishausen, Eisenach, Furtwangen, St. Georgen, Lenzkirch, Neustadt, Triberg, Villingen, and Rohrbach. Essentially a domestic occupation at its origin, and giving employment to whole families, it is only 35 years hat watch and clock making have been carried on in factories. Lentzkirch manufactures a large number of what are called Parisian watches, the zinc for the case being supplied from Paris and gilded here. The cases, wheels, and other necessary parts are made separately, and the work is divided nto various branches; the separate pieces are brought into the workshops, where they are put together, and clocks are successively mounted, tested, and regulated.

The different sorts of clocks manufactured n the Black Forest comprise:—Clocks with weights, clocks in cases, which include 2-hour clocks, 24-hour clocks, 8-day clocks, locks which go for a month, tower clocks, egulators, the spring clocks of English or French make, ships' clocks, and figure locks (amongst which may be classed "cuckoo" and "trumpet" clocks).

The importance of this branch of industry will be seen from the following figures:—n 1871, the Black Forest numbered 1,429 ree manufactories of clocks and watches, numbering 7,526 hands, independent of women and children, who were occupied in he small details; 13,000 persons lived by his industry alone. The number of articles produced had risen in 1871 to 1,800,000, of which 100,000 were of first-class workmanship. The total represented a value of 10 millions of florins. The most curious branch of this art is, without exception, the manufacture of automaton clocks. The great musical clocks are called orchestrals. n the manufacture of these clocks the work is not divided, at least for the essential parts. The masters execute nearly all in their workshops, with the exception of the metallic pipes. Last year there were 32 masters and 224 hands employed in making these clocks. The great factories of orchestral clocks produce instruments of 5 and 6 registers, of which the price varies from 1,000 to 20,000 florins. These clocks are in greatest demand in America and in Russia. —*Society of Arts Journal.*

Mechanical Vibration Retarding Rust. —At the recent meeting of the American Association for the advancement of Science, Prof. S. S. Haldeman, of Harrisburg, read a paper with the above title, of which the following is a brief abstract:—When railroad bars are piled beside a road they soon become rusted, while those forming the track are but little subject to oxidation; and when a rain of some hours' duration falls upon rails when in a state of rest, as upon Sundays, when trains do not run, they soon exhibit rust. This would seem to indicate that in chemical combination mechanical vibrations may interfere with the molecular arrangement of the elements. The accuracy of these casual observations should, however, be submitted to the test of experiment. In the discussion which followed this brief communication, it was suggested that possibly the oil employed upon locomotives might be more or less spread in a thin film over the rails in use, and thus prevent their oxidation. This view was earnestly combated by other speakers. Prof. Vander Weyde was quite certain that the suggestion of Prof. Haldeman bore reference to a fact in physics. Molecular vibrations tended to prevent rust. This was a general experience with tools.—*Iron.*

An experiment was made by Major Holmes, in a voyage from the coast of Guinea in 1665, which led the celebrated mathematician, Huygens, who was born in 1629, and died in 1695, and who had paid great attention to watches, and written a treatise on their use in finding the longitude at sea, to determine if possible to improve a watch for that purpose; but he found himself baffled by the irregularities of action caused by the alternations of heat and cold. In the "Philosophical Transactions" appears "A Narrative concerning the Success of Pendulum Watches at Sea for the Longitude," 1665, by Major Holmes. In the same work we find "Instructions concerning the Use of Pendulum Watches for Finding the Longitude at Sea," 1675, by Christian Huygens.

RAILWAY INSURANCE CHARGES.

At the sitting of the House of Commons on the 6th March, 1875, on the motion of Mr. Jackson, the following were nominated members of the select committee to inquire into the operation of the General Carriers Act, 1830:—Mr. Cavendish Bentinck, Mr. Brocklehurst, Mr. Maurice Brooks, Mr. Bruce, Mr. Campbell Bannerman, Mr. Freshfield, Mr. Gibson, Mr. Goldney, Mr. Staveley Hill, Mr. Laing, Mr. Leeman, Mr. Sampson Lloyd, Mr. Majendie, Mr. Morley, Mr. Pemberton, Mr. Salt, Sir Edward Watkin, Mr. Watkin Williams, and Mr. Jackson. The committee have elected Mr. Jackson their chairman; they commenced their investigation on Monday, 22nd March. After hearing the evidence of Mr. Buckingham and other gentlemen connected with the silk trade, which has no special interest for our readers, the committee adjourned.

All those connected with the watchmaking and jewellery trades, who have experienced loss or injury to their trade through the injurious incidence of the Carriers Act, are requested to communicate with the secretary of the Horological Institute, and, if possible, to attend a meeting to be held at the Institute on Friday, 2nd April, at 8·30 o'clock, with a view to their giving evidence before the committee.

Miscellanea.

The Municipal Council of Paris, after consideration, have decided not to place controlled clocks showing the standard of time at the corners of the principal thoroughfares of that city, thus following the action of the Corporation of the City of London, when the necessity of having standards of time was represented to them some years ago by the Council of the British Horological Institute. A distinction must, however, be made, for while the Corporation refused to recognise the necessity, the Municipal Council of Paris recognise the necessity, but plead the enormous cost of the scheme, and with some reason; for, after detailing the fact of Paris possessing 2360 streets, 113 avenues, 84 boulevards, 49 quays, 136 squares, and 58 passages, the projectors state the requirement to be 40,000 clocks! We do not gather from the report what these enthusiasts consider the principal streets, nor the number of corners each such street would have.

Electro-plating on China.—M. Hausen has recently patented in France the following process for electro-plating on a non-conducting material. Sulphur is dissolved in the oil of *Lavendula spica* to a sirupy contence. Sesquichloride of gold or sesquichloride of platinum is then dissolved in sulphuric ether, and the two solutions are mingled under a gentle heat. The compound is next evaporated until of the thickness of ordinary paint, when it is applied with the brush to such portions of the china, glass, &c., as are desired to be covered with the electro-metallic deposit. The objects are baked in the usual way before immersion in the bath.

The *Rêvue Chronométrique* for February contains an interesting account of proceedings in connection with the Society of French Watchmakers, on the occasion of distributing prizes to deserving workmen and apprentices for assiduity, long service, skill, and morality. The prizes consisted of medals, in gold and silver, and a collection of horological literature. In the course of his opening address, M. Emile Japy, president of the society, alluded to the English Watchmakers' Asylum and Pension Society in London, and urged the members of the trade to take the initiative in founding similar institutions for the assistance of deserving *artistes* who, through illness or other misfortune, were thrown into want. M. Japy concluded by asking the members present if French horologists should be less generous than their brethren on the other side of the Channel, and expressing a hope that in no distant future he should see a similar benevolent institution constituted, and prosperous in Paris, to the benefit of some and the gratification and joy of all.

The florin was first coined in 1849, in consequence of a motion made in the House of Commons in 1847, by the late Sir John Bowring, for an Address to the Crown in favour of the coinage and issue of silver pieces of the value of $\frac{1}{10}$ and $\frac{1}{100}$th of the pound sterling. The motion was withdrawn on the understanding that a piece of the value of $\frac{1}{10}$th of a pound should be issued, and this engagement was carried into effect by the issue of the florin.

In 1854 an inquiry was instituted, in pursuance of instructions from the Chancellor of the Exchequer, by Sir John Herschel, then Master of the Mint, to ascertain "how far the introduction of the florin . . . had been approved, and, if approved, how far on its

ierits . . . . . , and how far as a pre-
. stage in the transition to a decimal
e with the pound unit as its basis."

answers to this circular showed the
possible divergence of opinion among
nkers, to whom it was addressed, and
hardly appear to justify the conclusions
l at by Sir John Herschel, which were
able to the florin, both on its own
it and in comparison with the half-
; but the inquiries made were in so
instances considered in connection with
onvenience arising from the concurrent
ition of the half-crown and florin, and,
aested in the circular, in reference also
question of a decimal coinage, that it
icult to estimate with any degree of
ion the amount of favour with which
w coin had been received.

1861 their lordships directed Mr.
m, then Master of the Mint, to issue
r circular to bankers, requesting their
n on the subject of the comparative
nience and popularity of the two coins,
awing "special attention to the case of
rin on its own merits as an element of
apart from the presumption of its
a stage in the transition to a decimal
e;" and in 1862 Mr. Graham reported
irport of the replies which he had re-
. Of these 45 intimated a preference
ie half-crown, and 25 for the florin,
17 expressed no decided opinion; but
uld be stated that in a majority of cases
ion was taken to the concurrent circu-
of both coins, as giving rise to frequent
ces and inconvenience.

hough some further correspondence took
in 1863 and 1864 between the Treasury
ie Master of the Mint on this subject,
ps were taken to withdraw either coin
circulation; but the coinage of half-
s, which had been suspended since
was not resumed, while that of florins
ontinued. Arrangements having, how-
been made in 1871 for the systematic
rawal of worn half-crowns from circu-
, and the demand for silver coin in that
ie two following years having been ex-
e, not only was the number of florins in
ation found to have become larger than
f the half-crowns, but it became evident
he difference in the relative numbers of
oin would be rapidly increased.

EPSYDRÆ were introduced into Rome
one hundred and fifty-seven years
the Christian era; and by Pompey
use was commanded in the Roman judicial courts to regulate the lawyers in their pleadings. "This," says an ancient writer, "was to prevent babbling; that such as spake ought to be brief in their speeches." These clocks were very simple in their arrangement, being mere vases that were inverted by an attendant. Pliny incidentally mentions that each marked the third of an hour. This custom supplies Martial with a humorous allusion, where, describing a dull declaimer repeatedly moistening his throat with a glass of water during the progress of his endless harangue, he suggests that it would be an equal relief both to himself and to the audience, if he were to drink every time out of the clepsydra itself.

PHON PHYA BLASHA KARAWONGSE, who was lately commissioned by the King of Siam to forward a letter of invitation to British *savants* wishing to witness the approaching eclipse of the sun, is about to receive a mark of royal favour in the presentation of an English half-chronometer watch and gold albert locket (four other councillors of state being associated in a like act of approbation). They are from the *atelier* of Messrs. Barraud and Lunds, Cornhill. Each watch and appendage was enclosed in a casket of coromandel wood.

IN the latter half of the fourteenth century, about the year 1365-6, Edward III. caused a clock-tower of stone to be erected at Westminster, in the courtyard opposite the Palace or Hall, before the entry thereto, and near the site of the present clock-tower of the Houses of Parliament. This building contained a clock, which struck every hour on a great bell, to be heard into the hall in sitting-time of the courts, and the same clock in a calm might be heard in the City of London. The tower also contained other large bells, which, as Stow tells us, were "usually rung at coronations, triumphs, the funerals of princes, and their obits. Of these bells men fabled that their ringing soured all the drink in the town." Hence we may infer that their sound was as doleful as that of Big Ben before he was cracked.

In an Issue Roll of the forty-fourth year of the reign of Edward III, 1371, we find a record of the payment of two pounds, "To John Nicole, keeper of the great clock of the Lord the King, within the Palace at Westminster, taking per day sixpence for his wages for the custody of the clock aforesaid." This was for eighty days, from 24th October to 11th January. Henry IV. also appointed

a clockmaker, with a salary, to keep this clock in order. Frequent mention is made of "horologii Regis infra palatium Westm." in the Patent Rolls of Henry V. In the first year of his reign, 1413, are entries relating to the keeper, Hen. Breton, "valectus camere Regis." Among the effects of Henry V., enumerated in 1428, was "j'orlage, fait al manere d'un nief, l'argent preis' par estimation, lxs."

From accounts of the expenses of maintaining the Westminster clock and the bells in a state of efficiency, for three successive years, namely, the fourth, fifth, and sixth of the reign of Henry VI., it appears that Thomas, a clockmaker, received 13s. 4d. a-year as his salary for the general superintendence of it; and also 8s. for making the sail when it was broken, 6s. 8d. for amending the spring of the barrel, 12d. for the wire of the stobil, and 7s. for mending the nut and spindle. He was moreover paid for two great ropes, the one weighing fifty-two pounds, and the other forty-nine pounds, at the rate of three halfpence a pound; also for two ropes of thread for the little weight, 2s.; and for boards, laths, and mats, which were "bought for to stop the wind from the said clock, 22d." It is said that Henry VI. gave the keeping of this clock, with the tower, called the clock-house, and the appurtenances, to William Warby, of Walsby, Dean of St. Stephen's, together with sixpence per day remuneration to be received at the exchequer. These items of cost afford us a glimpse of what the old Westminster clock was; and we daresay that it was put up, set agoing, and kept moving, at far less cost and much more expeditiously, than the present clock, whose former silence and immovability have been the subject of many a smart joke. In the Acts of the Privy Council in 6 Henry VI., 1428, are accounts of repairs done to the "orelege," which supply some curious terms of the craft.—*Wood's Curiosities of Clocks and Watches.*

Advantages of Alloying Gold with Copper and Zinc.—M. Péligot communicated to the Académie des Sciences of France a valuable paper on the alloys employed for gold coinage. He states that the debates of the several Monetary Conferences which have from time to time been held, prominently show the prevalence of an opinion that the two essential points to be considered in the establishment of an international currency are the desirability of seeking in the gold standard a basis for assimilating the coinages of different countries, and the anxiety to maintain the universal adoption of the standard 900. The author considers that this anxiety is a serious obstacle to a common monetary system, and that it is possible by the selection of certain alloys of gold to produce coins which, being decimal as to weight, would be better adapted than those now in use for universal currency. He shows that by adding zinc and copper to the 20-franc piece, a coin might be obtained weighing 10 grammes, the triple alloy, which is easily produced, being perfectly malleable and of good colour. For instance, by melting a 20-franc piece with brass and copper in the following proportions as to weight—

	Grammes.
20-franc piece	6·456
Brass	0·894
Copper	2·650
Weight of the proposed piece	10·000

He obtained a satisfactory alloy of the following composition:—

	Milliêmes.
Gold	581
Copper	361
Zinc	58
	1,000

The advantage of this system would be that the uses of pieces of decimal weight would probably follow the gradual introduction of the metric system into other countries.

He thus concludes his paper:—"Avec des alliages ternaires au titre de 725 ou de 580 millièmes environ, il est possible de fabriquer une monnaie décimale de poids, ayant probablement les qualités qu'on recherche dans les pièces d'or qui circulent actuellement, et conservent toute leur valeur. Quoique personne assurément ne puisse songer à introduire inopinément une telle modification dans nos habitudes monétaires, il est néanmoins permis de rechercher, avec un sentiment purement platonique, quels sont les avantages que pourrait offrir une telle monnaie, au titre de 580 millièmes, par exemple."

The light gold coin imported into the Mint for re-coinage during the year 1873 amounted to £950,075, as against £778,000 in 1872, and the Bank of England were again the only importers.

Several instances of forging on watches the names of eminent makers have been recently brought to light. All possible vigilance should be brought to detect and expose this detestable fraud, the systematic perpetration of which proved so disastrous to the English watch trade at the beginning of the present century. Last month, a man being charged before Sir Sills J. Gibbons, at Guildhall, with stealing a watch entrusted to him to pledge by the complainant, who gave an address in Clerkenwell, pleaded that the watch was worthless, and that the complainant was getting his living in an improper manner. He went to sales and bought worthless watches, and then put new plates on them with other makers' names, and got dupes like him (prisoner) to pledge them. Eventually Sir Sills J. Gibbons said he should dismiss the charge, and he thought it was not creditable to either complainant or prisoner.

"To become a good watchmaker," says Berthoud, "it is necessary to be an arithmetician, in order to find accurately the revolutions of each wheel; a geometrician, to determine correctly the curve of the teeth; a mechanician, to find precisely the forces that must be applied; and an artist, to be able to put into perfect execution the principles and rules which these sciences prescribe. He must know how fluids resist bodies in motion, and be well acquainted with the effects of heat and cold in different metals; in addition to these acquirements he must be endowed by nature with a happy genius to be able to apply them all in the construction of an accurate measurer of time."

Letters to the Editor.

All Letters to be addressed to the Editor, at the Institute, 35, Northampton Square, E.C.

EXHIBITION OF MARITIME INDUSTRIES IN PARIS.

Sir,—I have the honour to inform you that I have been nominated by the Committee of Management of the International Maritime Exhibition of Paris for 1875 a Commissioner of the class for chronométrique and other instruments of precision connected with the navy. All applications connected with this class of the Exhibition should be addressed direct to me, in order that I may be enabled in the briefest possible time to arrange with the committee as to the necessary space for your exhibition groups. I shall feel obliged if you will give this publicity among your subscribers. By the post I send you particulars of the Exhibition.

A. H. RODANET,

Member of the British Horological Institute; Secretary of the Chambre Syndicale de l'Horologerie Française, 38, Rue Vivienne, Paris.

THE COMPENSATION ERROR.

Sir,—I am glad to see that further consideration is being given by your correspondents to the Compensation Error, and by continuing the discussion we may possibly be able to arrive at an ultimate solution of the problem.

In your last number Mr. Glasgow says that the statement, "that the time of vibration of the balance varies with the square root of the distance between the centre of gyration and the axis of rotation," is true in the abstract, but the law does not hold good when the elastic force of the balance-spring varies. This is quite true. He also says that the same law does not equally apply to the balance and the pendulum, because in the pendulum gravity is a constant power, whereas the elastic force of the balance-spring is continually varying by changes of temperature. This also is quite true. Had Mr. Glasgow stopped here, I should, in all courtesy, have thanked him for pointing this out, and for making a valuable contribution to the discussion; but, unfortunately, he proceeds to make further calculations and deductions, which are altogether erroneous. He says that if the elastic force of the spring be increased or diminished by equal amounts, the centre of gyration should not approach or recede from the axis by equal distances. He also says that if equal additions or subtractions be made to gravity, that the lengthening or shortening of the pendulum should not take place in equal quantities. This is an error.

By reference to any good work on the pendulum he will find the equation to the simple pendulum to be:

$$T = \pi \sqrt{\frac{L}{G}}$$

Where T is the time in seconds, π is 3·14159,* L is the length of pendulum in feet, and G is the force of gravity in our latitude, 32·1908.

$$\therefore \sqrt{\frac{L}{G}} = \frac{T}{\pi}$$

By squaring both sides of the equation—

$$\frac{L}{G} = \frac{T^2}{\pi^2} \therefore L = \frac{T^2 G}{\pi^2}$$

Now, taking this last equation for a one second's pendulum—

$$T = 1 \therefore T^2 = 1,\ \pi = 3{\cdot}14159 \therefore \pi^2 = 9{\cdot}86961.\quad G = 32{\cdot}1908.$$

$$\text{Then } L = \frac{1 \times 32{\cdot}1908}{9{\cdot}86961} = 3{\cdot}2616 \text{ feet} =$$

39·139 inches for a one-second's pendulum.

Now, let us add 10 to gravity, then :

$$\frac{42{\cdot}1908}{9{\cdot}86961} = 4{\cdot}2748 \text{ feet.}$$

Subtract 10 from gravity :

$$\frac{22{\cdot}1908}{9{\cdot}86961} = 2{\cdot}2484 \text{ feet.}$$

Then $4{\cdot}2748 - 3{\cdot}2616 = 1{\cdot}0132$ feet.

And $3{\cdot}2616 - 2{\cdot}2484 = 1{\cdot}0132$ feet.

Therefore, by adding 10 to gravity, we have to lengthen the pendulum 1·0132 feet to make it vibrate seconds, and by subtracting 10 from gravity, we must shorten it by an equal amount.

Now, the same law applies to the balance wherein the elastic force of the spring takes the place of gravity, and the centre of gyration must approach the axis of rotation or recede from it in equal ratios for equal changes of temperature.

Then I again ask, Why, in practice, are we compelled to make the weights approach the centre in a greater ratio than they recede from it ? I can account for it in no other way than by centrifugal force acting on the weighted rims of the balance in a greater ratio in heat than in cold, as stated in my former letter. It appears from the above that what I called the geometrical error only exists in the expansion and contraction of the arms of the balance, and, like that in the pendulum, is inappreciable for the small change in the centre of oscillation for ordinary ranges of temperature.

* In Sir Edmund Beckett's Treatise, 4th edition, page 42, by some accidental error he puts the numerical value of π as 2π.

Mr. Glasgow is surprised at my calling the rims of a compensation balance "springs," but surely he must have known that I was only speaking figuratively. I suppose he will concede that the rims are more *springy* after being cut than before.

Mr. Glasgow makes the remarkable query : "Whether the loss of elastic force of the balance-spring means anything other than its elongation by heat ?" By reference to the reports of the juries for the Exhibition of 1862, he will there find that the loss of time by the *elongation* of the balance-spring, by increase of temperature, is only 1-15th of its *elastic force !*

Equally incomprehensible is Mr. Glasgow's statement, "that it is the difference of arcs through changes of temperature only that the centrifugal force theory would apply to." From this it would appear that Mr. Glasgow has not comprehended what has been written about the centrifugal theory. Of course, the greater the arc of vibration, the more effective is centrifugal force ; but this has nothing to do with the theory suggested, which simply means that, if all the arcs be equal, centrifugal force has a greater influence on the rims of the balance when heated than when cooled.

In reply to Mr. Macken, I beg leave to say that the law, "that the times of vibration of the balance are as the square roots of the distance of the centre of the gyration from the axis," is referable only to a theoretical balance, where there is no friction on the staff pivots, and when the elastic force of the spring is always a constant quantity.

As some of your correspondents have asked how the Astronomer Royal obtained the result, that the balance-spring varied equally for changes of temperature, I enclose the rate of the chronometer on trial, which will sufficiently explain itself.

I am, &c.,

R. WEBSTER.

Queen Victoria Street.

ROYAL OBSERVATORY, GREENWICH.

Mean Daily Dates of Experimental Chronometer, Charles Frodsham, with a simple Brass Balance, *i.e.*, without Compensation, No. 3148.

1859.	Mean daily rate.	Difference.	Mean temperature.	Difference.	Mean daily variation for one degree of temperature.	Nature of trial.
	Seconds.	Seconds.	Degrees.	Degrees.	Seconds.	
June 22 to June 25	+ 45·9	...	68·7	...	...	
„ 25 „ July 2	+ 21·6	24·3	71.4	2·7	...	In chronometer room.
July 2 „ „ 6	+ 10·0	11·6	73·2	1·8	6·44	
„ 6 „ „ 9	— 142·5	152·5	99·3	26·1	5·83	
„ 9 „ „ 16	— 131·9	10·6	97·7	1·6	6·63	
„ 16 „ „ 23	— 45·2	86·7	83·8	13·9	6·22	
„ 23 „ „ 30	— 45·4	0·2	83·0	0·8	...	Exposed to heat in the gas stove.
„ 30 „ August 6	— 101·1	55·7	93·7	10.7	5·20	
August 6 „ „ 13	— 121·0	19·9	95·4	1·7	...	
„ 13 „ „ 20	— 28·9	92·1	81·8	13·6	6·78	
„ 20 „ „ 27	+ 11·8	40·7	74·6	7·2	5·66	
„ 27 „ Sept. 3	+ 54·7	42·9	66·7	7·9	5·44	
Sept. 3 „ „ 10	+ 50·5	5·8	66·4	0·3	...	
„ 10 „ „ 17	+ 83·9	23·4	62·7	3·7	26·3	
„ 17 „ „ 24	+ 86·9	3·0	61·9	0·8	...	In chronometer room.
„ 24 „ Oct. 1	+ 56·6	30·3	66·7	4·8	6·31	
Oct. 1 „ „ 8	+ 42·7	13·9	69·0	2·3	6·05	
„ 8 „ „ 15	+ 77·8	35·1	63·3	5·7	6·16	
„ 15 „ „ 22	+ 103·2	25·4	59·2	4·1	6·20	
„ 22 „ „ 29	+ 168·0	64·1	48·7	10·5	6·17	
„ 29 „ Nov. 5	+ 168·4	0·4	50·0	1·3	...	
Nov. 5 „ „ 12	+ 180·4	12·0	47·3	2·7	4·44	Exposed to external air under shed outside north window.
„ 12 „ „ 19	+ 225·2	44·8	40·9	6·4	7·63	
„ 19 „ „ 26	+ 206·8	18·4	43·8	2.9	6·35	
					103·83	
					$\frac{103·83}{17}$ = 6·11	
July 6 „ July 9	— 142·5	367·7	99·3	58·4	*6·30	Mean daily variation for one degree of temperature.
Nov. 12 „ Nov. 19	+ 225·3		40·9			

* This difference is caused by the chronometer having slightly accelerated on its rate.

The same Chronometer, with Compensation applied, gave the following results:—Mean Temperature—88 degrees, 55 degrees, and 82 degrees; Mean Daily Rate—0·0 seconds, 0·0 seconds, 2·4 seconds losing.

FLAT-RIM BALANCES.

Sir,—In answer to Mr. Kullberg's letter in the last number of the Horological Journal, permit me to state that the only knowledge I have of Mr. Kullberg's double-rim balance is through having seen it mentioned in one of the Greenwich rate-papers. I have never seen the balance, or known if it has four separate rims or two placed on two other rims, and have never inquired. I always believed I was the first who drew attention to the fact that a long action of the rims ought to improve the compensation, and I should have thought Mr. Kullberg would have been able to see, by the balance referred to being so near to his own in the Exhibition, 1862, that I did not get the idea of a long action from seeing his balance. As Mr. Dent's and Mr. Hartnup's flat-rim balances, as well as Mr. Kullberg's, were all well known at the time I wrote the letter quoted by Mr. Kullberg, it was unnecessary to make a complicated drawing, or give a description, because I had made flat rims. But I thought I would correct the mistake in the Journal, and draw attention to the principle on which the balance acted, well knowing others were quite as able to carry it out as myself.

I am, &c.,

F. KNUDSEN.

DRUM TIMEPIECES.

Sir,—In returning thanks to those who favoured me with a reply concerning these timepieces, I beg to state I have adopted "A. D.'s" plan—*i. e.*, reducing the thickness of the fourth and scape wheels, also the scape and pallet pivots. I have repaired five in the same way, and they have all given extreme satisfaction, going down to within a quarter of a turn of the mainspring (the full eight days). I agree with Mr. John Fewtrell that you cannot depend upon the sound alone for putting them on beat, but I cannot see my way clear in reducing the weight of pendulum-ball and thinning the rod, as he mentions. As a rule, the escapements are deep, and by doing it his way the clock must gain. How is that error to be cured?

Apologizing for having taken up so much of your valuable space,

I remain, &c.,

PLYMOUTH.

Plymouth.

To Correspondents.

G. Philcox.—*The substance of your communication has appeared in the Journal before.*

R. Jarman.—1. *At any of the tool shops.* 2. *It must have been some years ago. Very great distress prevailed among workmen connected with the watch trade in London in the early part of the present century. A relief society was organised, and in* 1817 *a committee of the House of Commons was appointed to examine witnesses, and report upon the causes of the distress.*

Cheshire.—*The last official return was issued in* 1867. *Although, probably, more gold cases are now marked, some of the returns of the number of cases marked at Goldsmiths' Hall* 80 *years ago show a larger aggregate of gold and silver cases together.*

A Manufacturing Jeweller.—*Your case is not an isolated one. By referring to another page you will observe that the House of Commons has appointed a select committee to consider the matter.*

Charles Hammar.—*Brass, if heated, is not harder from being plunged in water than if allowed to cool gradually.*

Will any of your correspondents say if the balance of advantage lies with lever pallets with equidistant lockings or circular pallets? Authorities I have consulted do not agree.—J. B.

Upon an old English clock I find the name of R. Webster, Salop. I should be glad of information as to the date this person existed. —H. H., Leeds.

I should be much obliged if one of your readers would tell me the best and most expeditious way of widening and polishing a jewel hole.—James Gough.

I should be glad if one of your subscribers would instruct me as to the method of setting out the duplex escapement correctly.—Apprentice.

Can you or any of your readers inform me at what date "Beeg, London," lived. That name appears on some very old watches.—D. Reid.

The Philadelphia Library claims possession of the oldest clock in America; it wants but a few years of being two centuries old. It was made in London, keeps good time, and is said to have been once owned by Oliver Cromwell.

British Horological Institute.

TREATISE BY MR. JAMES FERGUSON COLE.

a Council meeting held on Tuesday, il 2nd, an arrangement was concluded by ch Mr. James Ferguson Cole is to write the HOROLOGICAL JOURNAL a treatise on hronism, for which the Council have ed to pay Mr. Cole £100. Of this sum istinguished member of the Institute—Baroness Burdett Coutts—has offered to tribute £50. The remaining £50 the ncil propose to raise by means of a scription among the members of the titute, and the trade generally, feeling that there are a great number who will em it a privilege to contribute in comnent to Mr. Cole. Those who desire to e part in this subscription are requested communicate, as early as possible, with the retary of the Institute, who will acowledge the receipt of all sums in the ning number of the *Journal*. That the may not be of an exclusive nature, the ncil wish to limit the amount of any subscription to a guinea.

From the long practical experience of . Cole a valuable and exhaustive work y be expected. We are enabled to end a short programme, furnished by . Cole, of the head subjects of which he l treat; but although the first part of subject matter will be largely extracted m the manuscript papers intended by n for publication as a treatise on Horology ne years ago, as much is yet to be written, divisions or the order of them now en should not be taken as final.

HEADS OF SUBJECTS.

1. Introductory remarks relating to the jects and purposes of the essay.

2. Isochronism as relating to the balanceing in instruments for mechanical timeping.

3. Description of various modes of applying such springs.

4. Elasticity as a property of certain metals and other bodies suitable for springs in connection with such instruments.

5. Sonorous property of a metallic plate, held in the hand by a central wire, showing influence of heat in lowering its rate of vibration.

6. Experimental trials on a completed chronometer, with timing results from springs of greatly varied length, and their respective isochronal properties.

7. Effects of pivot-friction as causing variable extents of motion in the vibratory action of balances.

8. Arguments relating to balance-springs when made from wire of any number (say 10), the same 10-wire being drawn or rolled thinner than at first for showing the relative difference of effect when applied for experimental purposes.

9. Results showing how a defect of equilibrium in the balance operates to produce errors of position, which, through false judging, may be mistaken for an error of Isochronism.

10. Results of increased motive power as a means of correcting the loss of time in short arcs of the balance vibration, and thus proving how the motive force operates to diminish or correct an error of Isochronism as practically shown in a completed watch.

11. On the influence of the regulator curbpins as found to operate effectively for timing in long and short arcs of the balance vibration.

12. Definition of the centre of gyration in moving bodies, whether as relating to the chronometer balance, or to the pendulum of a standard clock.

13. On the sonorous property of metallic springs, their vibratory tone being the only indication of a natural Isochronism in such springs.

14. Mechanical influence of the balancespring on the two semi-arcs of vibration, theoretically considered and practically corrected.

15. Observations on the properties of balance-springs made from tapered wire, &c., &c., &c.

RAILWAY INSURANCE CHARGES.

A MEETING was held at the British Horological Institute on Friday, 2nd April, to select suitable cases of the injurious incidence of the Carriers Act upon the watch-making and jewellery trades to lay before the Select Committee of the House of Commons appointed to report upon the working of the Act; Mr. JOHN JONES, F.R.G.S. (Vice-President of the Institute), presided.

The CHAIRMAN said that a Committee of the House of Commons, having been appointed to consider the Carriers Act, mainly through the exertions of the National Chamber of Trade, it was thought that as the Act pressed heavily upon their trade it would be well to co-operate with the Chamber by calling the present meeting to select prominent cases of injury, and to hear any suggestions that the trade might have to make. A question has been raised as to a rate of insurance that would be satisfactory to the trade, and it would be well to hear the opinion on that point. The Post Office, with adequate arrangements, only lost one registered letter out of 15,000,000 carried, and there was no doubt that, with proper supervision, a very small rate of insurance would indemnify the Railway Companies. Among the letters which the Secretary had received upon the subject was one from a member of the Institute in Derbyshire, to which he desired to call the attention of the meeting. He would read the letter, and then it would be open for any one who had sustained any loss or obstruction in business through the provisions of the Carriers Act to give them their experience:—

"MY DEAR SIR,—I am very pleased to see in this morning's *Journal* that a meeting will be held at the Institute to-morrow to consider the Carriers Act, and hope the united efforts now making will be successful in getting it amended. I wish it was convenient for me to attend your meeting. I have been robbed more than my share by railways. During the last year I had one parcel stolen containing diamond rings value over £100, delivered by myself at Alfreton Station and signed for by the station-master; it was missing before the train reached Trent, a distance of only ten miles. Not one penny compensation have I received for this. During the same time I had three smaller parcels stolen, value £23 15s.; these being under £10 each, after considerable delay, I have compelled them to pay for. A few years since I had a gold chronometer stolen, which cost me nearly £40, and several other small parcels; so I wish your meeting success with all my heart.—I am, dear Sir, yours truly,

"D. BOWEN.

"Market Place, Alfreton.
"April 1, 1875."

"P.S.—I have thought if the Railway Companies would register parcels upon the same principle as the Post Office the transmission would be perfectly safe, and if stolen the thief would be at once discovered. I have suggested this to Mr. Allport; he replied by saying that they had the subject under consideration, and hoped would satisfactorily meet my case and all others similar."

After a full discussion, the following resolutions were carried unanimously:—

"That this meeting considers an universal rate of insurance for watches and jewellery in transit, irrespective of distance, within the United Kingdom, is most desirable."

"That in the opinion of this meeting a charge for insurance at the rate of 1s. 6d. per £100 value would satisfy the trade."

"That the following gentlemen be requested to give evidence before the Select Committee, if necessary—Mr. Bowen, Mr. Glasgow, Mr. Jackson, Mr. Oram, and Mr. Pickering."

The Secretary was directed to send a copy of the foregoing resolutions to the Secretary of the National Chamber of Trade.

The proceedings closed with a vote of thanks to the Chairman for presiding,

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The Select Committee appointed by the House of Commons to inquire into the operations of the Carriers Act (1830) met again, on Monday, March 12; Mr. Jackson in the chair.

After Mr. Smith, of the firm of George Smith and Son, wholesale furriers, of Watling-street, London, had given evidence as to the losses which his firm had on several occasions sustained, owing to the operation of the existing law as affecting carriage of goods,

Mr. ROTHERHAM was examined. He stated that he was a watchmaker at Coventry, where his firm has been established for a hundred years; it was the largest firm in Coventry; was a member of the Chamber of Commerce there; was in the habit of sending watches and clocks to retail dealers in all parts of the country. Losses occasionally occurred in the trade; those sustained in 1873 and 1874 by witness's firm amounting to upwards of £140, while those of the trade generally were about £1,000 for the same period. The number of losses in the trade in 1873

was six parcels; in 1874 the number of parcels on which loss incurred was thirteen; in April, 1873, witnesses firm lost a parcel valued £18 18s.; in December, 1873, they lost another parcel valued at £30 13s.; and in April, 1874, they lost a parcel valued at £90 11s. The last-named parcel was a box containing twelve watches, which were sent on approval to a retail customer in Staffordshire. He returned the watches to have his name put upon them, having purchased them; but when the box arrived at Coventry the railway company advised witness's firm that the box had been tampered with, the seals having been broken, and on opening it, it was found that the watches had been stolen. In another case the box contained two stones instead of the watches; and in the third, the box and its contents had altogether disappeared. Witness produced two letters which had been received from railway companies in reply to applications for compensation for losses. The first was from the office of the North-Western Railway, and was dated the 1st of October, 1873. It declined to entertain the application, on the ground that the parcel was over £10 in value, and was not insured. The other was from the Midland Railway Company, and was dated the 1st April, 1875. It declined to entertain the claim made against the company on the same grounds as those stated in the letter previously read. Was aware that under the Act a carrier was not freed from his liability notwithstanding that a parcel might not have been insured if the goods were shown to be stolen by the carriers' servants. There had been cases in which the consignors had entertained no doubt that the goods had been taken by servants of the railway company, but it was not possible to get at the inside of the railway company's system, and it was useless to proceed, except on the fullest and surest information. Witness thought that the clause only making the companies liable in case of theft by their own servants, was not a sound one in principle, although he would not say that the companies did not do their best to get evidence of how the loss occurred. Witness's firm had insured with Lloyds since the last loss they had sustained, and they did not, therefore, insure any goods sent by the railway companies. The terms asked by the railway companies were so high that they were absolutely prohibitory. The railway companies were under no obligation to insure goods beyond that which they undertook by their advertisements. As it was, none of the companies would insure goods sent to Ireland. The railway companies charged 5s. per cent. under 100 miles, and 6s. per cent. between 100 and 150 miles. There was a good deal of business carried on by the railway companies between Birmingham and Coventry, the distance between the two places being only 17 miles. A single parcel sent from Coventry to Birmingham valued at £100 would be charged 5s. for insurance, and if it were sent on approval and were returned the charge would be 11s. for insurance and carriage, whereas, on the other hand, a clerk or porter would be able to take the parcel to Birmingham and to return to Coventry for 3s. 2d. The charge for insurance by Lloyds in the same case would only be 1s. The claim by the railway companies to examine every package before insuring it would interfere very injuriously with business, and in most cases would be prohibitory. Witness produced four of Lloyds' policies, taken out by his firm during the present year. They were for £4,000 each, and covered every risk of loss, damage, destruction by fire, &c., both on the railway and in the streets. Witness's firm took out the policies at the rate of £4,000 a time, and every evening they advised Lloyds of the value of the parcels sent that day, when they were written off, and the process was repeated till the policy was exhausted, when a new one was obtained. Parcels of less than £10 value were not insured, because the railway company were liable for them. Had never had occasion to make any claim against Lloyds for loss. The practice of insuring with Lloyds was steadily increasing, as the terms and nature of the insurance were becoming better known. Their risk was greater than that of the railway companies, as they had no control over the transit, and the insurance covered all distances between places in Great Britain and Ireland. Witness's firm employed a broker in London to effect their insurances, and they paid him 6d. per cent. commission. There was every reason to believe that the whole charge would be reduced before long, inasmuch as the business was becoming a very lucrative one. The remedy he would suggest for the present system was that each consignor should declare the value of the goods sent by him over the sum that might be fixed, and that a small *ad valorem* rate of insurance should be charged. A rate of 5d. per cent. would, he was sure, be generally accepted and adopted, and, this being the case, he believed the railway companies would make a large profit.

Mr. Deakin, of the firm of Deakin and Moore, of Birmingham, wholesale jewellers

and jewellery merchants, was also examined. He stated that the business of the firm was principally in gold and silver, and was mostly confined to England and Scotland. He represented the views of the trade in Birmingham. The trade was one which was exposed to more than usual risks as to loss and with regard to fraud. They wanted their goods carried at a fair and a safe rate of insurance, and when they could insure for 1s. per cent. with Lloyds they could not see why they should pay 5s. per cent. to the railway companies. If Lloyds could make a profit out of 1s. per cent., the companies ought to make a profit out of 6d. per cent. Had there been such a rate on the part of the companies, witness's firm would have adopted it. He thought the charge should be, as in Lloyds' case, irrespective of distance. Witness had had no loss for twenty-five years, so that practically safety could be insured.

The Committee also sat on Monday, 19th ult., but confined themselves to the examination of witnesses not connected with the trades we represent.

On Monday, 26th, the first witness examined was Mr. James Slater, of the firm of Martin, Hall, and Company, of Bouverie Street, London, and Sheffield, manufacturers of electro-plate. His firm were not in the habit of insuring with the Railway Companies; he considered the rates prohibitive. In some instances silver goods would make four journeys between London and Sheffield in course of manufacture, involving four insurances; in his opinion 5d., or even 3d., per £100 in value would be a sufficient rate of insurance, and would induce manufacturers to insure; but he considered the liabilities of the Railway Companies, in the absence of insurance, should be raised from £10 to £20.

Mr. Deane, a member of the firm of Buller and Hutchinson, manufacturing jewellers, of Bartlett's Buildings, said that since October, 1873, they had invariably insured parcels over £10 in value at Lloyds. Before the date mentioned they preferred running the risk of loss to insuring with the Railway Companies. Since insuring with Lloyds they had taken out three policies of £1,000 each, and had not occasion to make any claim for loss. They also sent or received as many as 6,000 or 7,000 valuable parcels through the post as registered letters. He thought the Railway Companies should be expected to charge a less rate than Lloyds, as the Railway Company had every control over the parcels, which Lloyds had not; 5d. per £100 in value, he considered, would be a fair rate. The liability of the Company might be limited to, say, £4,000 or £5,000 in the case of any one parcel.

Mr. David Glasgow, watch manufacturer, of Myddelton Square, had been deputed, by a meeting of the watch trade in Clerkenwell, to represent to the Committee the oppressive incidence of the Carriers Act upon the watch manufacturers of Clerkenwell. He had found the high rates of insurance obstructive to business, and cited a recent instance where a customer had requested four or five costly watches to be sent for approval to Manchester; the witness refused to risk the goods uninsured, and found the insurance for the double journey prohibitive. He thought a low rate of insurance would induce manufacturers to insure.

INTERESTING EXHIBITS AT THE ROYAL SOCIETY SOIREE.

At the Annual *soirée* of the President of the Royal Society, recently held at Burlington House, was shown in one of the rooms on the ground-floor the original machine constructed by Heathcote, in 1808, which had the effect of reducing the price of bobbin-net lace from five guineas a yard to fivepence; *apropos* of which a quotation from Lord Bacon was given on the card—"For upon every invention of value we erect a statue to the inventor, and give him a liberal and honourable reward." In this room two of the prettiest and most instructive experiments were shown by Professor Barrett—namely, the lengthening of a bar of soft iron within a helix of wire by heat; the other, the remarkable and anomalous changes which take place in the heating and cooling of iron wire. Thus, whilst the iron is first heating there is a sudden contraction or cooling. And so again, when the heat is cut off, the wire cools a little and then suddenly reheats and glows, afterwards quietly passing down to a blackness. Now, the notable points of these jerks or changes are that the iron in the first instance loses its magnetism, and in the last jerk or oscillation regains it.

In the second room some simple delicate radiometers were shown by Mr. Crookes. These consisted of a glass stem supporting a little four-bladed windmill, carrying four discs, one on each end of the four slender

glass rays. These work horizontally, supported by a steel point on a small topaz, and the radiation of light from a common candle at some distance away suffices to make them rotate with great liveliness in vacuo in a small glass globe.

In the fourth room was a working model of Sir David Salomons' system of automatic railway signalling. Each engine is supposed to carry a battery and electric bell, and beneath it two metal wheels insulated from each other, and pressing down on a signal line of small rails laid on the centre of the sleepers. These central signal lines are double, and are laid in "block" lengths, one being a front signal line, the other a back signal line. On arriving at the termination of one block and the commencement of the next, one wheel will roll on the front signal line, while the other will roll on the back signal line, but at other places the left-hand wheel will be free. Now one wire of the battery and one from the bell are taken to earth by being simply attached to the engine, the current passing through the ordinary rails of the permanent way. If, then, whilst a train was on one of the "blocks" another train came on the same block, the bell on the engine of the following train would ring—a sufficient warning to stop and avoid danger. Side by side with the above was a fine induction coil by Mr. Apps, giving a spark of 21 inches, and a remarkably beautiful Gassiot electrical cascade. In this room was a fine polariscope with revolving double-image analyser, for showing all the phases of the polarisation at once in one field of view. One of these spots as seen through the instrument is either white or the complementary colour of the inner one, and as the rapidity of rotation is made to increase, the inner assumes the form of a white spot, having round it a ring compounded of several segments, each of which is a rainbow ribbon. The instrument was made for Dr. Spottiswoode by Messrs Tisley and Spiller.

In the principal library was a superb double-train spectroscope, belonging to the noble telescope made for Mr. Frank MacLean by Mr. John Browning, and in which the pretty novelty was noticeable of having the micrometer wires illuminated. There was in this room also a case of curiosities, which attracted much notice, which was the original memorial presented by the President and Council of the Royal Society to George III., praying that an expedition might be sent out to observe the Transit of Venus in 1769. This interesting document bore the signatures of the Earl of Morton, Nevil Maskelyne, Benjamin Franklin, and many other notabilities of that time. There were also in it the log-books of Captain Cook in his voyage round the world in the Endeavour—when the transit of Venus was observed at Tahiti, in 1766; of Captain Lutwidge, in his voyage of discovery towards the North Pole in the Carcass; and of Lieutenant Franklin in the brig Trent, in 1818. Mr. Ladd exhibited a small and very delicate thermo-electric apparatus invented by Dr. Lombard for the detection of the seats of disease in medical examinations of the human body. Applied to any suspected part the rise or fall of temperature is indicative of the portions or parts affected. On the table beside the model of the fine telegraph ship Faraday, Mr. Siemens exhibited some large fragments of rock which had been dredged up 1400 fathoms from the ocean depths in the laying of the United States cable. Two of these, of mica-schists, were of interest as being the droppings of icebergs in long. 44° 20′ W, and lat. 48° 53′ N, and the third was a mass of basalt dredged up from 2360 fathoms, in long. 24° 24′ and lat. 50° 31′ N, much nearer the Irish coast, and beyond the range of icebergs, being apparently pulled off a columnar mass *in situ*. Sir Wm. Thomson's tide-calculating machines bore the palm of the whole exhibition. By means of one observation, the rise and fall of the tides is made daily from the shore, and the facts so accumulated are the constants, and form the basis for setting the second or calculating machine, in which a continuous wire passes over a series of wheels placed at various distances, the result being that of harmonic motion of different periods and epochs by which the year's facts can be ground out by turning a handwheel, and recorded on the paper-carrying drum.

In one of the meeting-rooms on the ground-floor, Mr. Warren de la Rue showed some very pretty luminous effects of electric diffusion under the influences of increased atmospheric pressures.

TOUGHENED GLASS.

Although the manufacture of glass has been carried on for about 2,000 years, it does not appear that any attempts to overcome its inherent brittleness and liability to fracture, and at the same time to preserve its transparency, have proved successful—if, indeed, they have ever been made, which is doubtful. It is true that the French philosopher Réaumur many years since hardened glass somewhat by exposing it to a high temperature for a considerable time. But this process, which is technically termed devitrification, while it hardens, at the same time crystallises the glass and renders it opaque, the product being known as Réaumur's porcelain. Seven years since, however, M. François de la Bastie, a French engineer, after long and patient investigation into the subject, discovered a simple means of rendering glass practically unbrittle, and at the same time of preserving its transparency. There were many delicate conditions involved in the process by which he obtained this result, his success being achieved much in the same way as was Pallissy's, but on endeavouring to repeat the successful experiment he failed signally. For two years more M. de la Bastie, who possesses ample means, strove without avail to rediscover the secret of his success. At length, however, he succeeded in so doing, and has since been engaged in perfecting his invention and in developing a laboratory experiment into practical working. The process of conversion in the main is a very simple one, so simple that it seems singular it was never thought of before. Broadly stated, it consists in heating the glass to a certain temperature and plunging it while hot into a bath consisting of a heated oleaginous compound. There are, however, many conditions in connection with the details of the process upon which a satisfactory result depends, and the negect of any, even in a slight degree, constitutes the difference between success and failure. Thus, the glass may be underheated, and will not be susceptible to the effect of the bath, or it may be overheated and it will then lose its shape, or, again, it may be rightly heated and yet be spoilt in the course of transference to the bath. Moreover, the oleaginous constituents of the bath and their temperature have an important bearing upon the ultimate result. These and numerous other points of detail have all been satisfactorily settled by M. de la Bastie, who has designed furnaces and baths by means of which his toughening process can be carried out practically without fear of mischance. The time occupied in the actual process of tempering is merely nominal, for directly the articles are brought to the required temperature they are plunged into the bath and instantly withdrawn. The cost of tempering, too, is stated to be very small.

We have observed that M. de la Bastie went through a long course of experimental research before he attained success. He first worked, as an engineer naturally would, upon mechanical principles. Knowing that the fragility of glass results from the weakness of the cohesion of its molecules, he not unreasonably expected that, by forcing those molecules more closely together, and thus rendering the mass more compact, the strength and solidity of the material would be increased. But this doctrine, which holds good with iron and steel, as Sir Joseph Whitworth has practically demonstrated, does not apply to glass; compression failing to toughen it, even if applied to it when in a fluid or soft condition. By applying heat, however, which is only force in another form, the desired end is attained, and the physical properties of the material become altered in a very remarkable manner. To this singular fact we can testify from the inspection of a number of toughened glass articles at the offices of Messrs. Abel Rey and Brothers, 29, Mincing Lane, the representatives of M. de la Bastie in England. In these articles, which consisted of watch-glasses, plates, dishes, and sheet-glass, both coloured and plain, neither transparency nor colour is affected at all, and the ring or sound only slightly. These articles, some of them being exceedingly thin, were thrown indiscriminately across a room against a wall and fell spinning on the deal floor. Water was boiled in a saucer over a fire and the saucer was quickly removed to a comparatively cold place, and was unaffected by the sudden change of temperature. One corner of a piece of glass was held by the hand in a gas flame until the corner became exceedingly hot, but the heat was not communicated to the other portion of the glass, neither was it cracked from unequal expansion. A comparative experiment was then made with a piece of ordinary plate-glass, and a similar piece of toughened glass, in order to show their respective powers of resistance to fracture from the force of impact by a falling weight. In each case the glass was about 6 inches square, and was placed in a frame, the weight being dropped upon its centre. With the ordinary glass, a 2-oz. brass weight falling

from a height of 12 and 18 inches re-
vely did no damage, but at 24 inches
lass was broken into several fragments.
a thinner piece of toughened glass no
ssion was made by the same weight,
g from heights ranging from 2 to 10
the weight simply rebounding from off
lass. An 8-oz. iron weight tried at 2
feet respectively gave similiar results.
the height being increased to 6 feet,
ver, the glass broke. But here another
lar result was produced: instead of
ing into about a dozen pieces, as did the
ary glass, it was literally smashed to
s. The largest fragments measured
half an inch in length and breadth,
hese were easily reduced by the fingers
ms varying in size from that of a pin's
to that of a large pin's head. The lines of
res in the fragments presented to the
e appearance of irregular lace-work, and
lines were, moreover, apparent to the
, but more palpably so one side of the
than the other. Which of the two sides
e one that received the first impact of the
we were not able to determine. Another
arity is that the edges of the fractures
y no means so sharp, and therefore
le of causing incised wounds, as are
of ordinary glass. It would seem that
oughened glass possesses enormous
ve power, but that if the equilibrium
mass is disturbed at any one point the
bance or disintegration instantly ex-
throughout the whole piece, the atoms
ger possessing the power of cohesion.
the practical nature of M. de la Bastie's
e discovery there can be no question
ver, nor can there be any doubt of its
in the arts, sciences, and manufactures.
pplications which suggest themselves
numerable, and above and beyond the
ness of the process with regard to
s of domestic use come important con-
tions affecting the applied sciences,
lly in connection with chemical manu-
es and similar industries. For the
t there remains one purpose to
toughened glass cannot be so easily
d, and that is to window glazing in odd
inasmuch as it cannot be cut by a
nd or other ordinary means. The
can, however, be cut to the proper
efore toughening, if desirable. It is
engraved, either by fluoric acid in
nal way, or by Mr. Tilghman's elegant
ast process. It can be easily polished,
can also be cut by the wheel, as for
work and the like.

The Times.

HALL-MARKING OF JEWELLERY.

The following notice has been issued by the Society of Arts:—It having been brought to the knowledge of the Council of the Society of Arts that what is termed "Hall-marking" of jewellery and articles of gold and silver is inadequate to secure to the public that protection in the quality of the materials for which it is intended, and also fails to meet the requirements of the trade, they accepted the offer of one of the members of the Society, Mr. Edwin W. Streeter, to place £25 at their disposal, to be awarded as a prize for an essay treating on the subject, with suggestions for an improved system. Seventeen essays were sent in for competition, but as none of them were of a sufficiently comprehensive character to justify the committee in selecting any one for the prize, they recommended the Council, with the assent of Mr. Streeter, to renew the offer. Mr. Streeter having given his assent to this course, the Council now renew the offer of the prize. It is suggested to competitors that the essays should treat on:—

a. The history of hall-marking in this country, showing, with some degree of detail,

b. The processes adopted and now in use.

c. The merits and demerits of the present system, and how far it meets the wants of the public on the one hand, and satisfies the manufacturer on the other.

d. If any systems desirable, what should it be, and by whom and under what authority should it be carried out?

e. The systems in use in foreign countries, and how far they meet the wants both of the public and the manufacturer.

The essays must be sent in not later than the 1st of June, 1875, marked with a motto or cypher only, accompanied by a sealed letter, with the corresponding motto or cypher marked outside, giving within the name and address of the writer of the essay. The Council shall have the right of publishing the Prize Essay in the *Journal*, and they reserve the right of withholding the prize altogether, or of awarding a lesser sum, if the judges shall so recommend.

The Postmaster-General has issued a notice to the effect that by the laws of Austria the sending of letters containing articles of value, liable to Custom's duty, is prohibited. Letters containing such articles addressed to persons in that country are liable to detention till the Custom's duty is paid.

LEVER-END TOOL.

IN the hope that it may be interesting to practical watchmakers, I beg leave to give a drawing and description of a tool in my possession which, I believe, is but little known, and is used for polishing lever ends. It is besides well adapted for polishing the sides of fusee detent-springs, or in fact any hollow or round edge similar to the tail ends and forks of levers. The tool is a solid piece of brass of the size represented. Fig. 1 is a

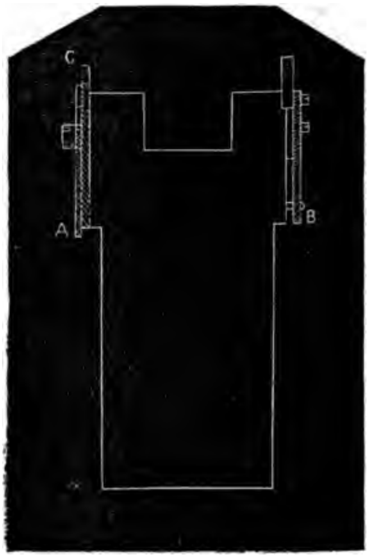
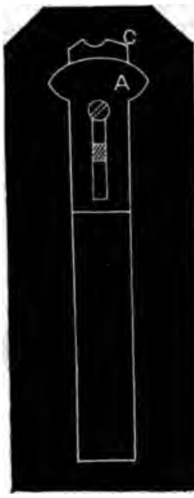


Fig. 1.

front view. Fig. 2 shows the side marked A, and Fig. 3 the side marked B in Fig. 1. A is a piece of steel with a slit down the middle, as will be seen by Fig. 2. This slit allows it to be raised or lowered as may be required to suit the corresponding surface. There is a square nib, or steady-pin, to keep it in position, and a screw to tighten it when adjusted. C is also a piece of steel, secured in the same way, but instead of being rounded at the top it has a small hollow formed. It will be understood that A and C are not used together, but when one is brought into action the other can be slipped down out of the way. B (the other extremity of the tool in Fig. 1) is a plate of brass, secured by two screws and a steady-pin.

If it is desired to polish the round end of a lever, the lever should be secured between the tool and the plate B, and A be raised so as to correspond with the lever, so as to ensure the ends when polished being at right angles to the sides, or square. The tool should be held in the right hand, and the lever end be polished on a block of metal in the usual way. No pressure must be applied; the weight of the tool alone is enough.



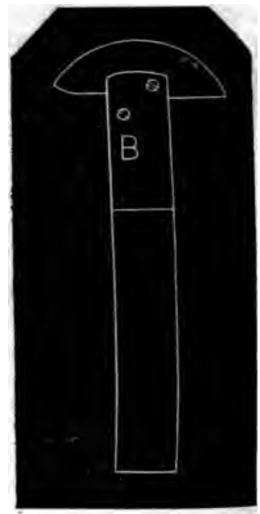


Fig. 2. Fig. 3.

To polish the fork-end of the lever a straight arbor should be inserted in the turns, the lever reversed, and C be brought into action (as in Fig. 2), and of course to such a height as will correspond with the lever fork. The tool should be held perpendicularly above the arbor, and moved slightly along it. The beauty of the tool is that it polishes quickly, and perfectly square.

As I have before stated, the tool is also used for polishing fusee detent-springs, but a small extra contrivance is necessary to gain this object. It is shown in Figs. 3 and 4.

Fig. 4.

The spring is fastened along the top of a semicircular piece of steel by a screw, and kept in position by a steady-pin. Both screw and steady-pin are shown in Fig. 4.

H. MYERS.

HE CLOCKMAKERS' COMPANY.

he *Times*' report of a dinner given by
Governing body of the Clockmakers' Com-
to a select company at the London
rn, the following occurs: "It is not,
ps, generally known that the Clock-
rs' Company has a name and history
ding over the long period of nearly two
ries and a half; a charter having been
ed to it in August, 1631, in the seventh
of the reign of Charles I. It was not,
ver, until 1766 that the guild attained
tatus of what is called, in civic nomen-
re, a livery company. In these later
, however, or perhaps as the members
selves would say, in these 'degenerate
' although the Company does not at
nt exercise any control over the trade,
intains, nevertheless, an active connec-
with it, and exerts itself as far as its
rs extend in promoting the interests of
lock and watch making industries. It
moreover, founded a library, containing
may be regarded as rather an unique col-
n of works upon the theory and practice
ock and watch making and horology in
al. It has also added to that a museum,
rating the progress of the art of watch-
ng from its commencement, and con-
ng many unique specimens. These
recently been deposited in the new
Library and Museum of the Corporation
e City of London, at Guildhall, where
are greatly admired. A nucleus has
been formed for a collection of portraits
minent men connected with the art,
h the guild hope will be the means of
cting further donations." We are cer-
y at a loss to know of what the
ive connection" at present existing
een the Clockmakers' Company and the
consists, or what the Company has
for at least a generation in "promoting
nterests of the clock and watch making
stries." It has, as the report truly says,
sited the unique specimens showing the
ress of the art of watchmaking, of which
d the custody, in the Free Library at
lhall; but this act was regarded by
r as severing the last link that bound
Company to the trade. However, as-
ng the report to be given with autho-
we shall be the first to express our
ration and gratitude upon observing the
test sign of this "active connection"
the clock and watch making industries.

PHILADELPHIA EXHIBITION.

Her Majesty's Government having accepted the invitation of the President of the United States to take part in the International Exhibition, to be held at Philadelphia in 1876, have placed the British Section under the Lords of the Committee of Council on Education, and the Lord President of the Council has appointed Mr. Philip Cunliffe Owen, C.B., Executive Commissioner. While the Executive will do all in its power generally to assist and advise British exhibitors, it will be understood by exhibitors that, in accordance with the precedents of previous International Exhibitions, they or their agents must be responsible for the packing, forwarding, unpacking, and reception of their goods, as well as for their safety during the continuance of the Exhibition. The salient points of the general regulations affecting foreign exhibitors, and the special regulations governing the free importations of exhibits as determined by the Centennial Commission are, so far as at present decided, as follows:—The Exhibition will open at Philadelphia on the 10th May, and close on the 10th November, 1876. Before 1st May, 1875, the British Executive must state whether the space allotted is sufficient or deficient, and should therefore receive the demands from proposing exhibitors before 25th April, 1875. Before the 1st December, 1875, the Executive must send in plans in detail showing individual allotments, with all catalogue information. There will be no charge for space. No charge will be made for a limited quantity of steam and water power. The quantity to be arranged at time of the allotment of space, and any excess of power to be applied for at same time, and to be furnished by the Centennial Commission at a fixed rate. Goods for exhibition are to be considered as bonded and exempt from Custom's duties. The usual noxious and explosive substances are prohibited. Exhibitors or their agents are responsible for the packing, forwarding, receiving, and unpacking of their goods, at both the opening and the close of the Exhibition. The owner, agent, or consignee must be present to receive goods. Reception of exhibits will commence on 1st January, 1876, and no articles will be admitted after 31st March, 1876. The installation of heavy objects requiring special foundations or adjustment should, by special arrangement, begin as soon as progress of works will permit. Space assigned and not occupied on the 1st April, 1876, will revert to the director-

general for re-assignment. All goods must, under penalties, be removed before 31st December, 1876. The objects exhibited will be protected against piracy of inventions or designs. Sketches, drawings, photographs, or other reproductions of articles exhibited, will only be allowed upon the joint assent of the exhibitor and director-general. The Centennial Commission will take precautions for the safe preservation of all objects in the Exhibition, but will not be liable. Facilities will be arranged by which exhibitors may favourably insure their goods. Special regulations will be issued concerning the exhibition of fine arts, the organisation of international juries, awards of prizes, and sales of special articles within the buildings, and other points not touched on in these preliminary instructions.

Mr. Owen will proceed to America early in June, returning in the course of July, in order that he may become personally acquainted with all matters of local detail of interest to exhibitors. He will be accompanied by Colonel Sandford, R.A., one of the official delegates appointed to assist in the Executive work, who will remain in Philadelphia, representing the Executive until Mr. Owen is able to take up his residence there in the early days of 1876, in order to superintend the labours of the installation, and to render to the exhibitors in the British Section all needful assistance.

Messrs. Cook and Son have been appointed Passenger Agents to the British Section, and will make, on behalf of the British Executive, the whole of the arrangements with the Atlantic steamers and railway companies for the conveyance of the exhibitors, their assistants, and workpeople, and also for the conveyance of the goods to be exhibited. —*Society of Arts Journal.*

CLOCK & WATCH MAKERS' ASYLUM.

A SPECIAL general meeting of the subscribers was held at the "Crown and Woolpack," St. John Street Road, on Monday, 19th April, in accordance with previous announcement; Mr. E. J. Thompson, Chairman of the Committee, presided.

In moving the adoption of the report and balance-sheet for the previous year, the Chairman said they had not been forgotten by departed friends, and, therefore, they had a substantial balance in hand arising from legacies. That was so far satisfactory, but he should have been glad if the balance had arisen from the subscriptions of the members of the trade. As the subscribers would have gathered from the report, arrangements had been made to build two new houses, one for which the late Mr. T. A. Taylor had left a legacy to build and endow, and which would be called the "Taylor Memorial House," and the other would be the result of the efforts of the "Workmens' Memorial House" Committee. He appealed to the subscribers to give the institution adequate support, now that trade was prosperous. Theirs was a charity, in the broadest sense of the term: their object was to save their aged members from the workhouse dole when they were in adversity, and provide them a home in one of the loveliest and most charming spots around London.

Mr. S. JACKSON seconded the adoption of the report and balance-sheet, and took occasion, as a member of the Finance Committee, to point out the fact that more subscriptions were required—the more they built the larger would be the sum annually required for expenses.

After a few remarks from Mr. Spring, Mr. S. A. BROOKS, in an eloquent and eulogistic speech, proposed that Mr. King, Mr. W. Clarke, of the firm of Clarke and Sons, and Mr. George Moore, be elected Vice-Presidents of the Institution. All these gentlemen had established a special claim to the gratitude of the subscribers by their devotion to the interests of the Institution.

The resolution having been carried by acclamation, Mr. Christopher Rowlands was re-elected Treasurer, and Mr. Brooks, Mr. Holliday, and Mr. Thompson were re-elected members of the Committee of Management. The Chairman then invited nominations to fill three vacancies in the Committee, and in response, Mr. Baxter, of the firm of Grimshaw and Baxter, Mr. Hartshorn, jun., and Mr. Stevens were proposed and declared duly elected.

The result of the ballot for the election of one male and one female inmate, which the Chairman then announced, had been awaited during the evening with considerable interest. Of the five candidates of whom we gave particulars last month, Mrs. Elizabeth Brittain and Mr. George Smith were elected by very large majorities. The proceedings terminated with a few words of congratulation addressed to the successful candidates by the Chairman.

CARILLONS.

In Continental cities bells have been made an eminent source of pleasure by mechanical means, apart from the mere striking of the hours and chiming of the quarters. Nor has this matter been unattended to in our own country and in this metropolis — as witness the carillon of St. Clement Danes, in the Strand, to which belated passers-by must often have listened with satisfaction. But there is a fault here, as indeed in many other cases of tune-playing church clocks, in the machinery adopted for the purpose, which is simply inefficient. The defective performance is due to the circumstance that hitherto in all carillon machinery the tune-barrel has had to perform the heavy work of lifting the bell-hammers. Now, seeing that the hammers vary very considerably in size and weight, it results that when a heavy hammer has to be raised, a much longer time is required than when a light one has to be lifted. Hence, the jerky, irregular character of the music produced, which will be executed rapidly with high, and slowly with low notes. It remained for Messrs. Gillett and Bland, of the steam clock factory, Croydon, to work out a marked and precise improvement in this respect, and to introduce a system of carillon machinery, which would interpret a tune or piece of music correctly. To effect this it was necessary to re-model the system entirely, the main point being to relieve the tune-barrel of the labour of lifting the bell-hammers, which duty is now imposed upon a secondary piece of mechanism. The primary duty assigned to the barrel is that of releasing a series of keys or detents, with which the studs in the barrel are made to engage as the barrel revolves. These keys act upon a series of levers, which are brought into contact with a cam-roller, and it is the cams and the levers together that effect the lifting of the hammers. This relieves the tune barrel of all strain, and the power of the cam arrangement insures regularity and precision at every stroke, whether on a large or a small bell. The motive power is obtained by weights, and the time is regulated by vanes, which are capable of easy adjustment. Messrs. Gillet and Bland's carillon apparatus has been adopted at Worcester Cathedral, St. Stephen's Church, Hampstead, the Town Halls of Rochdale and Bradford, and at other places. The most recent example, however, is that at the parish church of St. Leonard's, Shoreditch, which was opened at noon on Tuesday, and brought some excellent music out of the splendid peal of bells—one of the finest in London—which that church possesses. The machine is fixed in the chamber below the bells, and embodies all the most recent improvements by the manufacturers. The apparatus plays 14 tunes from two barrels, which have to be exchanged as each is played out. The arrangement of the tunes is as follows:—No. 1 barrel: Sunday, "Easter Hymn;" Monday, "Rose of Allandale;" Tuesday, "My Lodging is on the Cold Ground;" Wednesday, "the Sicilian Mariner's Hymn;" Thursday, "Lass o' Gowrie;" Friday, "Swiss Boy;" Saturday, "The Mermaid." No. 2 barrel: Sunday, "Rock of Ages;" Monday, "Annie Laurie;" Tuesday, "Ring the Bell, Watchman;" Wednesday, "Last Rose of Summer;" Thursday, "Blue Bells of Scotland;" Friday, "There's nae Luck about the House;" Saturday, "Home, sweet Home." These tunes are played on 12 bells, the tenor weighing about 34 cwt., and the peal ranging from CC to G. The carillon machine has 24 levers, two to each bell, in order to enable several notes in quick succession to be played upon the same bell when necessary. A tune will be played three times over, every three hours, day and night, the change of tune being effected at midnight by a self-acting shifting apparatus. By changing the barrels weekly a fresh tune will be played every day for 14 days; but any number of tunes can be played by having other barrels with seven tunes pricked on each. At the opening on Tuesday, each of the tunes was played in succession with excellent effect, and to the satisfaction of all interested, especially the crowd of parishioners and others who had assembled within the precints of the church to listen to the performance. Most of the tunes, especially the sacred ones, were given with precision; and if we notice the fact that in one or two cases a slight discrepancy was observable in the time, it is only to add that such may, to some slight extent, be expected where a comparatively heavy piece of mechanism is made the exponent of a delicately balanced melody. Messrs. Gillett and Bland, however, are to be complimented upon the great advance they have made in the direction of bell-playing, and the high degree of perfection to which they have brought their carillon machines. We may add that this firm are about to add two more bells to the peal at Worcester Cathedral, and to prick 21 fresh tunes.—*The Times.*

Letters to the Editor.

All Letters to be addressed to the Editor, at the Institute, 35, Northampton Square, E.C.

DUPLEX ESCAPEMENT.

SIR,—For the information of "Apprentice," who, in the April number of the *Journal*, asks for the method of setting out the Duplex Escapement correctly, I have extracted the following from M. Saunier's admirable work on Escapements, which will, I believe, answer his purpose.

Yours, &c.,
W. C.

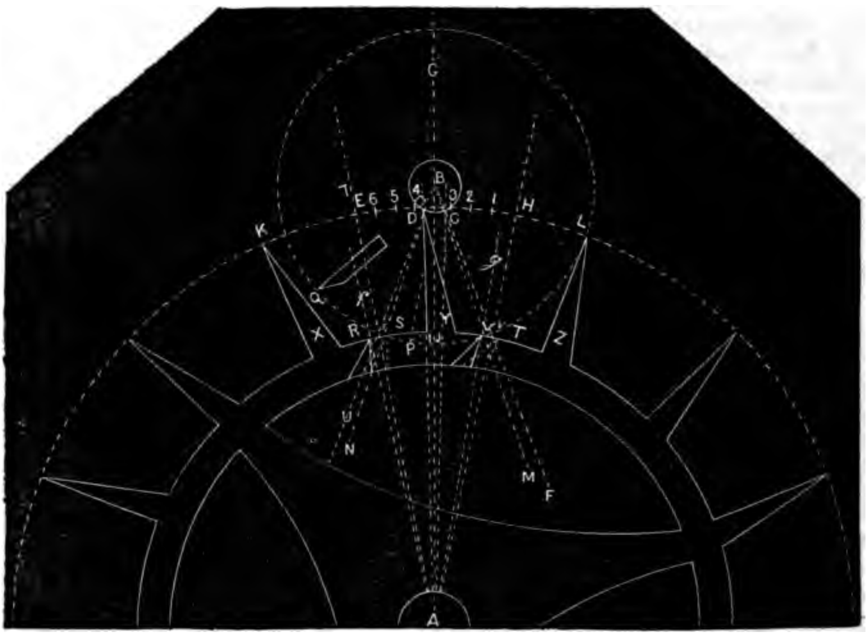


Fig. 1.

TO DRAW THE ESCAPEMENT.

In order to understand properly the effect of the moving of the parts of an escapement, and to find the exact proportions, one of the best means consists in drawing it larger first, and in every position. See how one shall proceed to trace the drawing of a duplex escapement, having, by supposition, a wheel of 10 millimètres diameter and with 15 teeth;—a roller of 2·7 mes.; a large lifting of 35°;—a small lifting of 30° (making this lifting upon the drawing 40°, in order to allow for the 10° lost ordinarily by the rounding of the lips).

The diameter of the wheel being known, this quantity is enlarged 20, 30, 40 times, &c., which makes a drawing of which every part in reducing it to the 20th, 30th, 40th, &c., gives the true proportions of the escapement. Ten millimètres multiplied by the number 30 give 300 millimètres, or 30 centimètres, for the diameter of the wheel sought, and 150 millimètres, or 15 centimètres, for radius.

Upon strong drawing-paper fixed upon a board placed for that purpose, draw the line of centres, AG, Fig. 1. With an opening of the compasses equal to 15 centimètres, and with point A for centre, trace the size of the wheel, or the arc of circle KEHL. Every circumference being of 360°, in dividing this last number by that of the teeth of the wheel (15), the result gives the opening for the teeth of this wheel (24°).

By means of a protractor from a case of mathematical instruments, make the angle EAH of 24°, and in such a way that the line of centres divides it equally, making the angle EAO equal to the angle OAH.

The distance EH representing the interval

from one point of a tooth to the following, divide this length (by compass or protractor) in 6, 7, or 8 parts, according as the roller is to be of 1-3, 2-7, or 1-4 measures. Here it is divided into 7 parts, as it is necessary, since the roller sought is to be of 2-7 measures.

With an opening of the compasses embracing one of those parts, describe separate, upon a piece of cardboard, for example, the size of the roller, Fig 2.

Upon the circle form the angle of 40°, dividing it in the middle by the line X. Then cut it round about, following the black line; this roller is placed above Fig 1, between B and G, sliding it along, taking care that the line X corresponds exactly with the line G A, until the two extremities of the angle *a* and *c*, of the angle *a b c*, Fig 2, having touched the circumference of the wheel K E H L. Then mark with a fine pin point, or the compass, the centre of the roller B and the two points D and C corresponding exactly to the two points *a* and *c* of the roller, which becomes useless after it is removed.

From centre B, Fig 1, trace the outline of the roller, and draw the two lines B D U, B C F. If it has been drawn with care, the angle U B F ought to be equal to 40°, and the circumference of the roller as well as the two lines B U, B F, ought to cut the circumference of the wheel at the same two points, D and C.

Through these points D and C draw from the centre of the wheel the lines A D, A C, the angle D A C shall be equal to the exact quantity through which the wheel moves during all the small lifting. The width of the roller notch occupies upon the drawing nearly 20°; to look at it is enough to be convinced that it offers more than the required surety, without drawing it nearer to the centres of motion. This opening only ought to be carried to 30°, in the escapements of which the small lifting goes beyond 50°.

There is now known the points of planting, or the centres of wheel and roller, the size of wheel, the size of roller, and the width of its notch, the angle of small lifting, the angle or the distance passed over by the wheel during all the small lifting; it remains to determine, —the angle of large lifting, the length of the finger and its position, the size of small wheel and the position of its teeth, the positions which the long teeth of the wheel of repose shall occupy.

The point of repose upon the roller is found at D, the line D A gives the place of the long teeth Y. Draw the two lines A K, A L, forming with the line A D two angles of 24° each; as this number represents the opening between two teeth, the long teeth shall be placed upon these three lines, A K, A D, A L, they are traced later. The tooth of impulsion ought to occupy the centre between two points of the long teeth: draw the two lines A *f* and A *g*, dividing in two equal parts the angles K A D, D A L. They shall serve to determine later the position of two teeth of impulse, since these cannot be placed better than upon those two lines.

From the centre of roller, trace the lines B M and B N, forming between them an

Fig. 2.

angle of 35° (large lifting), which angle the line of centres ought to divide into two equal parts, thus the angle A B M shall be of 17½°. The point V, where the two lines B M and A *g* meet, give—1st, the position of the impulse tooth; 2nd, the length of finger; and, 3rd, size of small wheel. With an opening of compass equal to B V, and from the centre of roller, trace the circle which fixes the length of finger Q P V. With another opening of compass equal to A V, describe from point A, as centre, the size of the small wheel R S V T.

Now ink in the long teeth, X Y Z, then draw equally in the black lines the small teeth V and R.

Measure the distance I J, that is to say, the opening of the two lines D A and C A. This distance serves to fix the removal of V

from T, and B to S. Since it is this quantity which the wheel advances during the small lifting, the two impulse teeth towards the end of this lifting are found in S and T; one is shown by the dotted lines

Mark the point P, observing to deduct from the arc S P a value of 10°, then with an opening of compass equal to the arc S′ P V′—that is to say, the arc of small lifting (40°)—determine from the point P, taken as centre, the point Q, which gives the position of the finger at the beginning of the small lifting.

The escapement is thus drawn in all its proportions.

Actually, if this escapement is supposed working, it is seen that, during the repose at the point D, the finger, accomplishes its vibrations dumb, shall pass in running past the tooth V, then at the return this finger is found at Q, where begins small lifting, running over during this small lifting of 40°, the arc Q P, equal to 40°.

During this running over, the finger, moving quicker than the tooth R, shall pass before it with a little play for safety, and it is only when it shall have come to P that this shall be found at S.

The point of the long tooth Y is found then at C, escaping from the roller, and the tooth of impulse S shall fall through 10° upon the finger represented by the dotted lines, and, pressing it forward the whole length of the arc P V, shall thus produce the large lifting, which is finished by the repose of the tooth X against the roller.

REMARKS.

The large lifting is only 25° in reality, since the 10° of fall are taken from the arc S P V. If it is wished that the action of the tooth upon the finger takes place during an arc of 30°, it is necessary to add to those 30° of lifting the 10° of fall, which shall make the angle N B M 40°, as in the small lifting.

The fall itself is not altogether 10°, the rounding of the notch angle makes it lose something. We have taken into account the difference, as it only complicates the operation. It is easily seen that drawing it cannot give exactly neither the freedom nor the play for safety. These small quantities can only be determined by the trying of the escapement in the pitching tool.

LEVER ESCAPEMENT.

Is a large Roller-Pin an advantage in unlocking?—W. J. S.

SIR,—Permit me to say a few words in answer to W. J. S., who is of opinion that a broad pin in the roller of a lever escapement overcomes locking resistances better than a narrow one. If the proportions of escapements are the same with round flatted pins, the capability to overcome locking resistance is the same in either case—it is simply a question of leverage; but if W. J. S. means to imply that the broad triangular pin is more capable, he is mistaken, for it is not equal to the small round pin. The round pin will fit the notch of the lever in every phase of its action, while the broad stone will fit only at the line of centres; and when in the act of unlocking the wheel, and at the completion of impulse, there will be excess of shake in the notch, producing a mechanical defect not existing with the small pin, if with a triangular pin the lever be moved from the line of centres to the extent of the lifting angle of a pallet, as, when in action, it will be seen that there is a considerable space the lever has to drop when the wheel is discharged. This is one of the constructive errors the springer has to contend with.

I remain, &c.

J. L. TILLING.

DRUM TIMEPIECES.

SIR,—In reply to "Plymouth," I beg to state that he is altogether mistaken in supposing that a drum-clock will "gain" with a lighter pendulum, as, by thinning the rod and turning the upper half of the ball into a conical shape, we actually lengthen the pendulum, that is, we lower the centre of gravity and also the centre of oscillation. I hope "Plymouth" will understand from this that the weight of a pendulum must be in proportion to the "motive force" of the clock; for instance, a turret-clock may have a seconds' pendulum of a hundredweight or more, whereas, a house-clock or regulator's pendulum weighs but a few pounds. For any further information on this subject I beg to refer "Plymouth" to Sir Edmund Beckett's Treatise on Clocks, &c.

JOHN FEWTRELL.

Birmingham.

THE COMPENSATION ERROR.

SIR,—I am still perplexed over the question of the centre of gyration. If Mr. Webster is right in stating that the times of vibration of balances are as the square roots of the distance of the centre of gyration from the axis, provided we neglect friction and always keep to the same balance-spring in the same condition—for that, I presume is what he means—all I can say is, I cannot find out what law of motion will meet the case. It does not agree with the force of gravity acting on different pendulums, because to double the time of vibration the centre of oscillation must be removed to a fourfold distance from the axis, and at this fourfold distance from the axis we may conceive the mass to be collected and gravity to act; so that this is quite a different case to the same balance-spring always acting at the same distance from the axis.

Neither does the statement agree with the law of motion of a rigid body about a fixed axis, for in this case the initial velocity would be proportionate to the moment of the force divided by the moment of inertia of the balance, and the final velocity would be the aggregate of the successive additions of velocity by the spring.

Perhaps Mr. Webster would not mind pointing out in whose mechanics, and in what article, we can find the law treated on in the way he states, and also oblige by giving the name of the publisher.

Respectfully yours,

JOHN MACKEN.

15, Clarence Street.

SIR,—In the Table of Mean Daily Rates of chronometer No. 3148, published in your April number, there is a typographical error of considerable importance. In the column "mean daily variation for one degree of temperature," and line September 10 to 17, the figures 26·3 should be 6·32.—I am, &c., R. WEBSTER.

SIR,—While we must all concur in Mr. Glasgow's remarks respecting the varying power of a balance-spring in different temperatures, as distinct from the force of gravity which is uniform, this is not sufficient to account for the irregularity known as the "secondary error." Neither does Mr. Immisch's theory of centrifugal force offer us a satisfactory explanation. A simple experiment will convince any one of this. A chronometer balance that has been rejected on account of some imperfection, *before it has been cut open*, will answer the purpose, and save the spoiling of a good one. Being provided with such a balance, drill two holes on opposite sides of the rim, where the compensation weights are usually placed, and, having tapped them, fit two heavy-headed screws,* with the heads *inside* of the rim, and apply the balance to a chronometer.

Having got it to time, with the screw-heads pretty close home to the rim of the balance, keep the chronometer in an even temperature, and give the screws one turn each 24 hours, carefully noting the variations in time, and it will be found that the nearer they approach the centre of the balance, the greater the secondary error will become; that is to say, each alteration of the screws will cause a less variation in the rate than the preceding one. Now in this case the error cannot be accounted for by the altered strength of the balance-spring, for the chronometer is kept in an even temperature; neither can it by centrifugal force, for the balance is not cut open.

Before the introduction of the pendulum, clocks were provided with a *balance*, that is to say, a horizontal bar equally poised on a vertical axis, the same as De Wick's clock is represented with. These balance clocks were regulated by means of weights that were screwed on to the extremities of the arms. The action of these weights would be to increase or diminish the moment of inertia according as they were moved nearer the centre or further away from it. I hoped to have been able to give the result of an experiment with a balance of this construction, but have not been able to spare the necessary time. In theorising about mechanical actions we are, perhaps, too apt to lose sight of the disturbing influences we meet with in practice. The weights are but a part of the entire weight of the balance: while they move, a large portion of the balance remains uniformly the same. It is not possible for the weights to be attached to a balance without any specific gravity, but the simple De Wick balance comes the nearest to this condition.

Yours obediently,

NEMO.

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* The Author gives a drawing, showing these screws applied to a balance, which time will not allow us to engrave.

SIR,—I cannot accept Mr. Webster's conclusion that the time of vibration in a pendulum is in direct proportion to the amount of gravity's force.

This appears to me to be in direct contradiction to the axiom that the velocity of a moving body varies as the square root of its impelling power.

There is an obvious printer's error in the equations in my former letter at the foot of page 97, for which I am not responsible; but to remove any misapprehension that may exist, I may as well re-state them as they should have been.

With the force of gravity decreased from 10 to 9:

$$\sqrt{\frac{(39\cdot15^2 \times 9}{10.}} = 37\cdot15.$$

And assuming the force of gravity to be increased to 11:

$$\sqrt{\frac{(39\cdot15^2) \times 11}{10.}} = 41\cdot06.$$

I have no desire to occupy your space with a controversy that can neither interest nor instruct your readers, or I would answer separately each paragraph of Mr. Webster's letter.

Mr. Webster lent the weight of his authority to a theory of the errors of the compensation-balance, which I believe to be erroneous, and on that theory he suggested a remedy which I know to be impracticable; that is the position I have taken up, and I cannot see that Mr. Webster's last letter has weakened my position or strengthened his own.

Yours, &c.,
D. GLASGOW.

WE have received from Mr. Cohen a letter calling attention to the difficulty of readily obtaining the correct time in passing along the streets of London, and suggesting the more general adoption by watchmakers who have regulators or other time-pieces facing the street, a push-piece, or other convenient arrangement of setting the timekeeper to mean time every day. Mr. Cohen truly remarks that good watches are often mistrusted through the unreliable standard of time exhibited.

IN Sir John Soane's Museum, Lincoln's Inn Fields, is a thick silver watch, which was formerly in the possession of Sir Christopher Wren, who died in 1723.

To Correspondents.

I shall be much obliged if any of your readers will give me a description as to how the connection is made in the great and ratchet wheels and barrel in the maintaining power of clocks. What is the position of the connecting spring, and what strength should it be for a going weight of 40 lbs.?—R. L.

Having lately come into possession of a very fine old long-case chime clock, with the name of John Kay, London, on it, I shall be very glad if any of your readers can tell me the date of his residence in London, and any other particulars respecting him.—R. L.

In answer to JAMES GOUGH, *who asks for the best and most expeditious way of widening and polishing a jewel hole; the method I adopt is as follows:—The hole is chucked in the lathe with cement. A spirit-lamp being placed underneath to prevent the cement hardening, a pointed bit is held against the hole and the lathe kept running until the hole is true, when the lamp is, of course, removed. The broach to widen the hole should be made of copper, of the size and shape required, and the point after being oiled should be rolled in diamond-dust until it is entirely covered. The diamond-dust should then be beaten in with a burnisher, using very light blows so as not to bruise the broach. After the hole is widened as desired, it requires polishing with a broach made of ivory and used with oil and the finest diamond-dust, loose (not driven into the broach).*—H. B.

P. DRAYTON.—*De Vick's clock was fixed in the tower of the palace of Charles V., about* 1364. *A full description was given in Vol.* I. *of the* JOURNAL. *It is too long to reproduce.*

APPRENTICE, *who asks concerning the calculation of Watch and Chronometer trains, should make his inquiry more specific. Does he desire a rule for calculating generally, or the number of teeth in the wheels requisite for some particular number of vibrations?*

J. B., *who asks if the balance of advantage lies with equi-distant lockings or circular pallets, should read Mr. Cole's Lectures and Discussions, published in Vol. I. of the* JOURNAL. *Each kind contains an advantage and a defect, and either answers well, when properly made.*—R. FOULGER.

WE desire to direct the attention of our readers, particularly those who are engaged in watch case or dial engraving, to the programme issued by the Goldsmiths' Company, which is published in full on the cover of this number.

British Horological Institute.

Paper read before the Members, May 19th, 1875, by RICHARD WHITTAKER, 8, Eton Grove, Dacre Park, Blackheath, London; Mr. JOHN JONES, F.R.G.S. (Vice-President), presiding.

"THE object of the present paper is to explain certain patented improvements in keyless going-barrel watches.

"1. The watch winds up in the usual way, by turning the button or knob on the pendant forward, as shown in Fig. 1.

"2. The setting of the hands (see Fig. 2) is accomplished by pulling out the knob, but before you can pull it out, you must unlock it. It is unlocked by turning the button back about half a turn, and at the same time applying considerable tension; then the intermediate wheel B will leave the barrel wheel C, and enter the minute wheel, and by keeping a slight tension, the operator may then set the hands as desired; turn the knob forward, the hands will move forward, turn it back, and the hands will move backward. Immediately you leave hold of the knob, the intermediate wheel B flys out of the minute wheel and assumes the position as shown in Fig. 1; the knob is then held or locked down, and the wheel B cannot come in contact with the minute wheel, except by repeating the operation of turning back and pulling out the button simultaneously. If the operator wishes to set the hands several hours, say 11 hours or more, and he finds the continued tension inconvenient, he may place his finger or thumb nail in the groove G, Fig. 2, turned in the pendant, and then set the hands backward or forward as much as he pleases. On leaving hold the self-locking will be performed as before.

"The locking is simply caused by the three wheels, A B C, being planted in a straight line, instead of planting them in a triangle, as in mechanisms in use, and is not a complicated arrangement of springs, bars, and bolts, as the word locking sometimes imports, hence you see the object of turning the button back; this causes the intermediate wheel to traverse the periphery or circumference of the wheel A, and free it from, or leave the gearing of the wheel C. In other words, the locking is the gearing of the wheels A B C, planted in the line of centres.

"As this is one of the parts in which my mechanism differs from anything in use, I will here give you my reasons for this departure from the various modes of setting the hands. 1st. We have found that those mechanisms which set the hands by pulling out the knob, are liable to be pulled out accidentally and so stop the watch. This cannot take place in my arrangement, as it requires a deliberate act on the part of the wearer to establish the connection between the keyless and motion wheels. 2nd. When the knob has been pulled out designedly, for the purpose of setting the hands, it is often left in that position by careless wearers, and instead of setting the hands to time it has stopped the watch; this is always liable to occur in the hurry of business, and especially in a good watch, the alteration of the hands being of rare occurrence. You will see my mechanism provides for this contingency, for immediately the watch has been set to time the keyless wheels leave the motion wheels without requiring any act or after-thought on the part of the wearer. 3rd. Those mechanisms which have a push-piece on the band of the case (and they are by far the most numerous) are liable, under unfavourable circumstances, to have the push-piece pressed down, and so set the hands backward or forward or stop the watch. Much skill and ingenuity has been employed to remove these defects; for instance, a pipe with a nick in it has been soldered into the case to protect the push-piece; this remedy is as bad—perhaps worse—than the disease, as it forms a channel for any fine subtance to press the push-piece down more effectually. Others have a pin or wedge soldered on the cover of a hunting case, or on the bezil of an open-face case, and when shut down, passes through the band of the case and presses against the push-piece; this effectually prevents accidental setting of the hands when the case is shut, but is most objectionable from its frequent liability to catch in the dress, &c., when the cover of the hunting case is open, and is also objectionable in the open face, which requires exposure of the hands when setting them to time, and in both instances is objectionable on account of the perforating of the case, which forms inlets for dust, &c. None of these objections can apply to the mechanism before you; it has no push-piece, which is unsightly and unsound; the

case is not perforated, and it is not necessary to open the glass bezil of an open-face watch when you set it to time. If you set the hands in a cloud of dust, in a storm at sea, or in a shower of rain, none of these elements can obtain admission in the watch.

"I will not detain you by examining more of the hand-setting arrangements, but commend to your notice a valuable article, by Mr. Grossmann, in the *American Horological Journal* of 1872, which is in the library of this Institute, where he examines a great number of hand-setting arrangements, and lays before you fully and fairly the objections that rest against them, and he arrives at the following conclusions :—'I have always thought,' he says, 'that the setting-hand mechanism ought to be constructed in such a way that,—1st, the motion wheels can never come in contact with the keyless wheels by any accidental cause; on the contrary, they should be so arranged as to require a decided act on the part of the wearer to establish their connection with the motion work. 2nd, after having set the hands, the said mechanism ought to go out of gear with the minute wheel by its own action, and without requiring any care whatever on the part of the wearer. These two principles,' he continues, 'are of the utmost importance for the good and reliable service of the watch, for a watch invariably stops if the keyless mechanism comes into or remains in gear with motion-work at a wrong time; and a construction which requires a degree of care which not all wearers bestow on their watches must be called defective, so long as other constructions may be attained without this weak point.' I respectfully submit, the mechanism before you embodies these important principles set forth by Mr. Grossmann.

"The next part I wish you to examine is the arrangement of the barrel, barrel-arbour, and stop-work. The barrel-arbour (see Fig. 8) has two pivots for the barrel to work upon, the stop-piece and click-wheel are attached to it by means of a left-hand screw formed on the lower part of the arbour; a pivot is turned on the stop-piece and fits in the lower plate, and comes flush with the bottom of the sink turned out for the wheel C, Fig. 2. When the click-wheel is screwed on it slightly binds the arbour to the plate. The advantages derived from this arrangement are as follows :—The barrel is held in its proper position without a name-bar or top-plate, and allows the barrel to be made a little higher than the top of the balance-cock, and by this means the height of the mainspring is increased more than 50 per cent., without adding to the thickness of the watch; this arrangement admits of a broad thin mainspring, which gives six turns to the barrel, and consequently approximates to an adjustment, and yet there is ample power to the watch. The arrangement of the going-barrel in our keyless movements I have always regarded as very objectionable. I refer to the great waste of valuable space. In their present form it is not possible to get more than 4½ turns to the barrel, and then there is barely sufficient power to the watch. The movement before you is worked into a case the same depth as is required for one with 8 pillars, and yet the height of the mainspring is 15 degs. on the douzieme gauge, instead of one of 9 degs. on the same gauge if worked on the old system; and though the spring is so thin as to give over six turns to the barrel, and consequently is near to an adjustment, yet there is ample power for vibration to the heaviest balance that can be got into the watch—results that I am sure cannot be obtained with the present system of making going-barrel watches. Here let us not lose sight of other great advantages a high thin mainspring has over a narrow thick one. Competent spring makers assert that the difference in the temper is as follows:—After a thin spring of good steel has been hardened, it requires to be let down to a dark red-blue or puce colour, and a thick spring of the same quality of steel and work requires to be let down to a light or white blue; and, notwithstanding the increase of temper, the thin spring is least liable to break. It has greater force in proportion to a thick one, and retains its force immensely better.

"So great do I conceive the advantages of my barrel arrangement to be, that I think they might with profit be applied to our ¾-plate fuzee watches; though they do not lack power, it is derived from a thick and low-tempered spring.

"The mainspring is hooked into the barrel by cutting a tongue in the spring, which catches into a very shallow nick inside the barrel—just a scratch from the point of a graver is sufficient; this method of hooking in the spring works admirably. I think it advisable to make two or three of these scratches at equal distances from each other, and this will allow the spring to be set up so that the stopwork will act near the end of the last turn; this, I venture to think, is a great improvement on drilling a hole, which weakens the edge of the barrel, and screwing in a pin which projects through the spring, and throws the barrel out of

truth when the spring breaks; by this means, and its increased height, my barrel is better fortified against the breaking of the spring. These may seem little points, but to neglect them is to make a watch the engine of its own destruction. In this construction the barrel work is easily made, firmly fixed, infallibly upright. It saves the thin and complicated bridge, and about fifteen screws, as used in Geneva watches.

"The next part to examine is the stopwork. The weak part in a going-barrel stopwork is the boss on which the star-piece is screwed. This may be greatly strengthened by springing on the star-piece. I think it advisable to increase the size of the stopwork, so that the star-piece comes close to the teeth of the barrel, and by this means get a larger and more reliable boss. This will not apply to Geneva watches, as a little more than a third of the barrel must be turned away to free the hour wheel. But the improvement to which your attention is directed, is the bevelling of those parts of the stopwork which come into action when the watch is wound up, and when it has gone down. These bevels are so formed that, when the watch is wound up, the edge of the finger-piece overlaps the edge of the star-piece; this causes the shoulder of the barrel-arbour to bind hard on the inside of the barrel, which is left large and quite flat. This binding is of itself a kind of stopwork, and, to some extent, relieves the pressure from the boss; at the same time, the overlapping presses the star-piece close to the barrel, and prevents its well-known tendency to rise. This is substantially the improved action when the watch is wound up. The bevels at the other end of the stop-pieces are formed with lower angles, and in opposite directions, which gives a slight tendency to throw off the star-piece; the object of this action is to prevent the irreparable injury to the boss, which takes place when the click spring breaks, or when the mainspring is let down with a rush by accident or carelessness on the part of the workman.

"We pass on to consider what I regard as the most important part of my invention, viz., the form of the shifting-bar and spring, its mode of application, and its combination with setting flange, and also the bearing for the bevel-wheel in the pendant. I will briefly describe them, the mode of application, and tell you what I conceive to be the advantages. Fig. 7 is the shifting bar and spring. It may be formed out of one solid piece, or the pivot on which the intermediate wheel works may be screwed on to the bar (see models). One of the plate-screws passes through the hole on which it works; after the sinks are turned out for the keyless wheels, a chamber is cut through the plate under the wheels A B, Fig. 2, and the bar and spring fit in this chamber, which has room for it to work; the bar then rests upon the under surface of a solid top plate. Advantages:—By this means the entire thickness of the lower plate is devoted to the wheels and shifting-bar, or, in other words, 150 per cent. is added to the thickness of the wheels, and 50 per cent. to the thickness of the shifting-bar, without adding to the thickness of the watch. 2nd. It brings the wheels close to the dial, and yet makes it easy to apply the shifting-bar under them. The present system of placing the shifting-bar above the wheels and close to the dial is a fatal mistake, as it brings the wheels near to the middle of the movement, necessitates fine teeth, and excess of leverage in winding. The arrangement before you admits of coarse teeth, which are cheaper to cut, easier to work, and far more durable in action. I find it best to make the shifting-bar and spring out of one solid piece, and screw in the pivot on which the wheel B works; the bevelled pinion in the pendant is formed with a sleeve to it, through this sleeve a piece of steel, called the setter, works, in combination with the shifting-bar, so that when the knob or button is pulled out, it causes the bar to move in the direction of the minute wheel (see Figs. 3 and 4). When you leave hold of the knob, the spring causes the bar to return to the barrel. The spring is cut out of the bar with a screw-head-file, or it may be easier made by screwing the bar in a slide rest and cutting it with a circular saw. The end of the spring comes a little below the centre of the hole in which it works. The action is somewhat akin to a gunlock-spring, and may be said to be a spring of speed rather than one of power. The bar may be moved through an arc of 35 degrees, and the action of the spring is scarcely perceptible considering its great thickness, the lowness of its temper (for it acts remarkably well when quite soft), and the little action, it is impossible for it to break.

"The bearing of the bevel-wheel (see Fig. 6) is formed of hard steel, and is let into the top plate under the wheel A, Fig. 1. A hollow drill is passed through the pendant, and forms in it a hole or bearing, in the centre of which a pivot is left for the setter to rest upon, and so forms a bearing for the bevel-wheel.

"The present system of making keyless watches without a bearing for the bevel-wheel

is absurd, and yet it is not without advocates, for some tell us a bevel-wheel depth will not wear shallow, and others go further and say it wears deeper. I have hardly patience to deal with these statements. Suffice it to say that no depth wears more than an angular or bevel depth. Intelligent mechanics laugh at us for our want of engineering skill. What are the results? How does it work? In a few years the depth misses altogether. I can supply you with plenty of instances of this kind, where the watch has not been going more than four or five years, and some even less than four years. Of late it has been found necessary to make the watch with squares and keyholes. I have seen this in the highest class of work, so that when the keyless work gives way, the wearer may be able to wind up his watch with a key. I am aware some tell us the reason for their being made with squares, &c., is in case the watch should get into the hands of a country jobber, and he might not be able to repair or put it together; this is untrue. The squares and keyholes are a tacit acknowledgment of the unsoundness of keyless watches. In the mechanism before you there is no liability to give way.

"The winding knob or button (see Fig. 9), in its present form, is objectionable. When new and left with sharp edges it is unpleasant to use, and painfully so to a delicate lady; its sharpness cuts the dress, and, worst of all, it soon wears smooth and slips through the fingers, and then it winds with difficulty. My improvement consists of one made octagonal shape, fluted, and is analogous to our board key. I find by it the power is more easily transmitted, and at the same time it is free from the objections already mentioned. With regard to its appearance, some think it better looking than the one in use, while others say it is ugly. It would not be modest of me to determine these questions, but they should be carefully considered before it is adopted. All I claim is that it has the mechanical advantages already described. Mr. Nicole, a maker of keyless buttons, is present with a specimen; he suggests to have the top nurled, and I think the bottom of the fluting might be improved by engraving or chasing. The price for making, he says, will not be greater than the present form of button, a statement, I apprehend, that is true of all that I have shown you to-night.

"Before I leave this part of my subject, let me say a word respecting the proportion of the turns of the knob to a revolution of the barrel-arbour—a point on which there seems to be considerable difference of opinion. I have found from 3½ to 5 turns of the knob to one of the arbour. Mr. Grossmann recommends three turns of the knob to one of the arbour. The majority of our English mechanisms require more than four turns, and it cannot be denied they wind too easy; and in no construction of watch does this excess of power work worse results than in a going-barrel lever, for by it the wearer unconsciously forces the stop-work, not unfrequently bends the teeth of the barrel and centre-wheel, and gives a dangerous impetus to the balance, and an amount of torsion; but for these defects in winding the watch might take an irreproachable rate. In the open-face model I have used a pinion of 16 in the pendant and a wheel of 40 on the barrel-arbour, which requires 2½ turns of the knob to 1 of the barrel, and, notwithstanding the increased power of the mainspring, with the improved button, it winds sufficiently easy.

"The click and click-spring (see enravings (is formed out of one solid piece, or the spring may be screwed or riveted on the click if desired. The spring is attached to the head of the click at the point A, Fig. 1, instead of the tail, as in those in use. By leaving the spring a little below the centre of the hole in which the click works, the spring may be left strong, and yet have a light and desirable action. The click works on the thread of a screw which passes through the lower plate, the head of which forms a strong and desirable steady pin for keeping the plates steady. I have not seen this method of attaching a click-work in a watch, but have frequently seen it in well-made turret and house clocks. Now, the point to which your attention is more especially directed is the remedy supplied for what is known as torsion, or extreme tension. This takes place when the watch is wound up to the top, and by the wearer giving extra force the click presses against the tooth of the wheel and strains every part of the watch. From this moment it acts under the full power of the spring. Increased by the action of this torsion, it begins to work violently, and continues so for some minutes. This is always accompanied with no small danger to the escapement, and produces a considerable deviation of rate. The remedy is this,—make the point of the click to come nearly in a straight line with the barrel-arbour and click-screw, and allow the front of the click to bear upon the plate into which it is sunk; this gives to each tooth a little recoil, and so prevents the torsion complained of.

"Hunting-case lock-spring (see Fig. 5).—

Our saddle lock-spring to hunting-cases is expensive, and an impassable barrier against a bearing to the bevel-wheel. The one I have invented receives its motion from the side of the pendant, the point A passing into a slot-cut in the pendant between the band of the case and the movement. It is not more expensive to make than the most ordinary case-spring.

"Dial fastening.—The dial-feet are made in the shape of an inverted cone. A spring on the top-plate takes hold of this cone, much in the same way as you would hold it with your finger and thumb. All the forms of screwing on dials are objectionable, and in the present construction of watch it cannot be pinned on.

"The next improvement is what I call pressure-proof. The top-plate is made out of a solid piece of brass, and fits on and is screwed to the lower plate without pillars. The index or regulator is made a little below the general surface of the top-plate, so that any external pressure goes on the solid top-plate, which is able to bear it. This is a matter of considerable importance where the watch has a thin gold case with flat bottoms. The scape-cock is formed on the solid top-plate, or, rather, it is left when you turn out to free the balance. It is not liable to shift, and has conditions of strength not to be met with in the present form of ¾-plate escapements.

"In review of the whole matter, I venture to assert I have shown you a mechanism of far greater *strength, simplicity*, and *efficiency* than anything as yet produced. I have accomplished more with three screws in the watch than is done with 45 screws in the best Geneva watches. I have made the mechanism with one wheel and two pinions—and one of the pinions is more easy to make than a minute wheel-nut; to accomplish more than best mechanisms in use, some of which have nine wheels. The spring, which is so simple and scarcely worth mentioning, accomplishes more than is done in some mechanisms I have seen with four springs.

"I claim to make the watch thief-proof, water-proof, air-proof, and dust-proof, as well as pressure-proof."

The CHAIRMAN said it would probably be premature to speak of the practical value of Mr. Whittaker's propositions. They would have an opportunity of reading the paper in the *Journal*, and considering the various points, before arriving at a final decision; but a discussion of the views which had been placed before them would be interesting, and no doubt Mr. Whittaker would give any further explanation desired.

In the course of a somewhat desultory discussion which followed, remarks were made by Mr. F. Hough; Mr. Schoof, who thought it ungenerous to inventors of other keyless mechanisms to say that leaving squares on was an acknowledgment of unsoundness of the keyless work; the squares were useful for winding and letting down before the movement was in the case; he considered the exertion required to keep the knob out while setting the hands rather objectionable; by the Chairman, who thought the squares were in some degree an impeachment of the keyless work; by Mr. Bickley, who feared the arrangement for hooking in the mainspring might fail and allow it to slip in the barrel; and by Mr. Prowse.

A vote of thanks was unanimously accorded to Mr. Whittaker, on the motion of the Chairman, who expressed the indebtedness of the members to Mr. Whittaker for the trouble he had taken to lay his thoughts clearly before them by preparing the models which were exhibited.

Mr. Cole's Treatise.

THE following amounts have been received or promised in answer to the invitation of the Council to contribute to the fund required:—

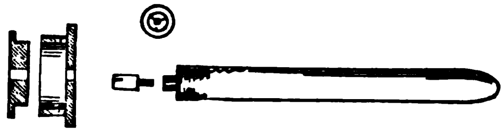
	£	s.	d.
Mr. Bacon	1	1	0
Mr. Bickley	1	1	0
Mr. R. Bushell	1	1	0
Mr. W. B. Crisp	1	1	0
Mr. Dawes	1	0	0
Mr. Evans	1	1	0
Mr. Ganney	1	0	0
Mr. Glasgow	1	1	0
Mr. Hollister	1	1	0
Mr. Immisch	1	1	0
Mr. Jackson	1	1	0
Mr. Jones, F.R.G.S.	1	1	0
"Lemas"	1	0	0
Mr. Mayer	1	1	0
Mr. Peter Orr	1	0	0
Mr. Snaith, Wigton, Cumberland	0	5	0
Mr. Strachan, F.M.S.	1	0	0
Mr. Webster, F.R.A.S. ...	1	1	0
Messrs. Usher and Cole ...	1	1	0

ARRANGEMENTS have been made for a party of the members of the Institute to view the magneto-electric clocks of Sir Charles Wheatstone, and other objects of interest, at the British Telegraph Manufactory. Particulars of this and other announcements will be found at page xi. of the advertisement space.

ON MAKING AND APPLYING BALANCE-SPRINGS.

ALTHOUGH your *Journal* has contained a good deal on this head lately, the growing importance of the subject will warrant my giving a few practical suggestions on the making and applying balance-springs to watches. Thirty years ago every finisher made and applied a spring to the watch he finished (except a very few of the best watches, which were sprung with what were termed hand-made springs, turned up, as described by Mr. Palmer in his essay, or the ordinary tool-spring, hardened between two pieces of brass screwed together—a very clumsy and almost impossible way of hardening a spring and keeping it in shape). Now, very few finishers know anything about either making or applying them. About this time Mr. Lutz, of Geneva, discovered a method of hardening springs (other than the old process of fire and water) and imparting a very beautiful appearance to them. He exhibited a case of these springs in the Exhibition of 1851, which came into my possession afterwards; and very beautiful things they were, in all forms and colours. I believe the Commissary gave him some assistance to enable him to perfect his invention; but I do not think these springs have improved since then, although the secret is still a family one. Great quantities of these springs, and others made in imitation of them, have been brought to this country, superseding the old tool-spring of the finishers, as they deserved to do; but they are altogether unworthy of a good English watch (although too frequently applied to watches receiving that appellation), as the process of hardening, whatever it is, destroys the steel, and if at all hard makes it brittle and rotten.

I will now describe the process of making good springs, beginning with the ordinary flat spring. Take a piece of brass or German silver, about the eighth of an inch thick, drill a hole in the centre and turn it out in the mandrel to about $\frac{3}{8}$ of an inch in diameter, in the form of a small watch-barrel. This is called a spring-box. Fit a lid to it, also with a hole in the centre; turn down a piece of brass wire with a pivot and shoulder to fit



Spring-box and Winder.

the small hole in the box, and projecting a very little way through (it should project through the bottom of the box the exact width of the wire to be used for the springs). Tap a small hole in the centre of this winder-pivot and cut three thin slits in a triangle to receive the ends of the wire, of which the springs are to be made. Drill three holes at equal distances through the rim of the spring-box, close to the bottom, through which pass the wire and fasten the ends with a screw into the slits in the winder; the head of this screw should project through the hole in the cover. Now the cover is to be put on and gently pressed down during the process of winding the springs up, until the box is quite full, the ends of the wire cut off, the screw removed from the centre, and the winder taken away. Bind the cover tightly down with wire, stop the hole in the centre (animal charcoal and soap will do for stopping), and harden the whole in the usual way. Water is better than oil, as the lower the temperature at which they are hardened the better the springs will be. If the box is now put into a small vessel (an old metal spoon will do) filled with oil, and held over the spirit lamp until the oil just catches the flame, and then left to cool, they will shake out of the box quite easily, and you now have three springs that, even in this state, are far superior to the spurious Swiss things called hardened and tempered springs.

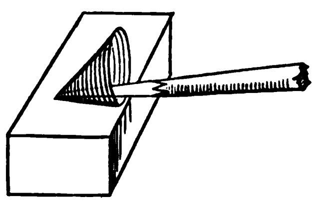
If the air is effectually excluded, the process of hardening will not discolour the steel much, and tempering in oil very little, there-

fore little time is required to polish a spring carefully made after this manner.

Polish them in the following way :—Take a piece of wood or large pith, make it into a cone at one end, put a pin into the end to project half an inch ; put your spring over this pin, and draw down the outer

To Polish Outer Sides of Coils.

end of the spring over the cone with the thumb of the left hand, and with a well-worn brush well charged with red stuff you will, in a few minutes, polish the outer sides of the coils ; turning the spring when one side is polished, and repeating the process. The inner sides of



To Polish Inner Sides of Coils.

the spring are more difficult, and require care and practice. If the spring be placed on a piece of flat cork and a finely-cut peg be inserted through the centre, and pressed firmly on the cork, the spring will take the form of a cone, and by moving the peg (with plenty of red stuff on it) backwards and forwards, and also in a lateral direction, the inside of the spring will be polished in a few minutes ; care being necessary not to bend the spring, as if bent in the polishing ever so little it is useless. The flat edges of the spring are polished on writing paper rubbed over with red stuff, by pressing the end of the middle finger on the spring, and moving it gently in a circle. Some use cork or pith instead of the finger. Wash the spring in benzoline, and it is ready to blue. Care and experience are necessary to blue a spring well, but the practice will repay the trouble and time.

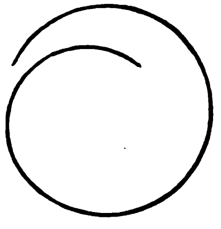
The tool for making the Breguet-spring must be somewhat different, as only two of these springs are made at a time ; therefore, all that is wanted is a slit cut across the pivot or small part of the winder. The pivot should project a quarter of an inch through the box, and two, instead of three, small holes made in the side of the box. The wire, to give the requisite number of turns in the

Winder for Breguet-springs.

flat-spring in a given size, must be flat and broad ; but when two only are made at a time, the wire should be very little flattened, else the coils of the spring will be too close together. The reasons for a difference in the lengths of flat and Breguet-springs will be given. The spring can now be applied to the balance, without being pinned to the collet, but merely sprung on, as the centre should be small, and the time of the vibrations counted. It will be seen if the spring is the exact strength, and if so, and the exact size, it should be pinned in so that the inner and outer ends of the spring terminate exactly at the same point, forming a complete circle, or what is termed "equal turns."

If the spring is now pinned to the collet, and the collet put on a small arbour, by moving it round alternately in the callipers and turns, it will be got true and flat ; if for a Breguet-spring, the outer coil must be turned up not less than a whole turn ; it should be bent upwards and over in a very

flowing curve, carefully avoiding what Mr. Henry Philips Palmer, in his *valuable* prize-essay, calls "elbow-joints," or the sharp angles to be seen in all springs of this form applied to Swiss watches. The end of the over-coil should run into the stud-hole before being pinned in, and if the stud is screwed into the cock without the balance, it will easily be



Breguet Curve.

seen if the jewel-hole is in the centre of the hole in the spring-collet, as it should be. This spring should also be pinned in so that the inner and outer coils will form a complete circle.

The isochronism of the balance-spring is a subject bristling with controversy; but, as I am writing this with a hope that it may be useful, I will avoid theorising as much as possible, and treat it from my own personal experience. There are, however, a few dogmas in the way which I must notice.

First comes the venerated axiom of Dr. Hooke, "*Ut tensio sic vis*," which is not quite true of balance-springs of watches, else every spring would be isochronous. There is, again, an absurd theory, attributed to the late Mr. C. Frodsham (recently repeated in your *Journal*), that every length of spring has its isochronous point; and, in a recent prize-essay, the writer, Mr. Immisch, says, "every one, with some experience in timing, knows that mere length has absolutely nothing to do with isochronism."

Now, I assert that length has everything to do with it, and I am not "copying the statement from books," as I know of no books in which the statement is made, but am making the statement from my own experience; and, first, I affirm that a spring too short, whatever its form, will make the short arcs of the balance's vibration be performed in a less time than the long arcs, and that a spring too long will have just the contrary effect; and, for this reason, if you take a balance in its place in the watch with a spring of ten turns (a length often prescribed), and move the balance round half a turn—you will find that while the inner end of the spring, being pinned to the collet, moves round in the same circle as the balance, the outer end being fixed, the disturbance in the spring taking place first in the inner coil has gradually affected the fixed and rigid end, and in a spring of this length (especially if it is a hardened spring, and therefore more elastic), the maximum resistance of this fixed end has been reached, or nearly so, therefore if you move the balance another quarter of a turn in the same direction, you have added little or nothing to the resistance, and the spring has not force enough to throw the balance back through the longer arcs in the same time that it would have gone through the shorter. Therefore, I assert that a spring with ten turns is too short, and, in consequence, a watch with a spring of that length will lose in the short arcs and gain in the long arcs. Now, take a spring of twenty turns, and go through the same operation, and you will find that the balance must be moved through more than the half turn to disturb the fixed end of this spring; but as the spring is more than double the length, it is also thick in proportion, and when the disturbance reaches the rigid end, it exerts a force sufficient to carry the balance through the longer arc in a shorter period than before that force was called into action. I repeat, then, that a *flat* spring with ten turns is too short, and one with twenty too long; that the spring with ten turns will make the same watch go fast in the short arcs, and the spring with twenty turns slow in the short arcs. I find the best length for a flat spring to be 14 turns; and if it is half the size of the balance and pinned in, as before directed, the time will be pretty near in positions; but although the flat spring is the most common, it is also the worst form of spring; it cannot expand on the side next the stud, but has a dragging, lateral action, while it throws out on the opposite side to a third more than its proper size, causing considerable pressure of the balance pivots on each

side of the holes alternately. It will assist the action of this spring if it is always a little small, as this gives more freedom to that portion of the coils next the stud. I have seen directions by good men how to time in positions by the curb-pins; this should never be attempted. The curb-pins (always an evil) should be just wide enough apart to let the spring just move between them, and no more, and should never be far from the stud; and as "manipulating," as it is termed, the curb-pins is only done with the object of lengthening or shortening the acting length of the spring, this should be accomplished in the proper way at once, by adding or taking away weight from the balance. Should the watch, with the spring referred to, gain a few seconds in the short arcs, taking up the spring half the width of the stud, and replacing two of the balance-screws with heavier ones, will remedy this defect, and should it do the reverse, that is, lose in the short arcs, by taking a very little off the weight of the balance, and letting the spring out so much, the error will be corrected, that is, if the error is in the spring; but no directions will enable any one to make a watch go well, with bad pivots, bad holes, and large and bad lever escapements.

The Breguet-spring, although differing very little in form from the flat spring, is essentially different in action and principle, the over-coil being fixed above the spring and nearer the centre gives it perfect freedom to expand in a circle all round. This spring must be much longer than the flat spring, as the force of the outer or fixed end is sooner reached, and the curve inwards gives it more power of resistance, and also an easy and perfect means of obtaining isochronism. I find from twenty to twenty-two turns the best length for this spring, and curb-pins should never be used with it if perfect timekeeping be aimed at. I would also warn anyone against attempting to alter the shape of the pivots of the balance-staff; there is only one shape for pivots, and spoiling the pivots is not isochronising the spring. This remedy is nearly as bad as putting the balance out of weight to obtain time in positions. My theory is length, and length alone, and this theory seems to me to be in perfect accord with the result of a good many experiments on this subject, most of them pursued unconsciously. As, for instance, the tapering of the wire before making the spring, and again, in the contrary direction, when what was termed the isochronous stud (that is, a long spring stud) was used; and I have actually seen these two remedies applied to one watch, when the result might have been obtained by a spring of the proper length.

I need not mention any of the other forms of spring in use—they are beyond the scope of the present paper, but they are all governed by the same laws, and their action is nearly the same as the Breguet-spring. There is still a feeling in favour of the cylindrical spring for pocket chronometers—I suppose from old associations, and as there is generally room to get a spring long enough in it is a very good form.

But when the great merits of the Breguet-spring (properly made) for pocket watches are better understood, it will doubtless be more generally used than at present, as high-class watches that can be relied upon for keeping correct time are every day becoming of greater importance. I shall, perhaps, be told that adopting a good deal of what I have said means higher-priced watches. No doubt it does; and I cannot help thinking that the reasons why fewer really good watches are sold in England than in other countries with a tithe of its wealth, must be sought for amongst the makers and sellers, and not the buyers of watches.

In a country where "Time is money," more now than it has ever been before, and where so much is spent in art and luxury, why should excellence in watchmaking be the only excellence not worth attaining?

I do not think what I have said will enable a person that has no title to the name of watchmaker to spring a watch. There is no royal road to the art of watchmaking more than to any other, but I am afraid it is too much the feeling amongst a portion of the trade to look for information from books and what are called "*trade secrets*," which can only be obtained at the bench. I think, however, there is information in this paper that ought to be useful to those seeking

knowledge; I know it is the result of much thought and labour to myself. I believe I have made it quite clear what is the principle of isochronism in the balance-spring, and how that isochronism is to be obtained, and, I hope, exploded the greatest of these trade mysteries, that are the very meanest things associated with watchmakers.

D. GLASGOW.

RAILWAY INSURANCE CHARGES.

THE Select Committee of the House of Commons appointed to inquire into the operation of the General Carriers' Act met again on Monday, 10th May, Mr. Jackson in the chair.

The first witness was Mr. Sellon, a representative of the firm of Johnson, Matthey, and Co., gold refiners and bullion dealers, Hatton Garden. He said their business was a large one—he believed the largest of its kind. It had been established 125 years. The nature of the business was that they supplied bullion to the large dealers throughout the country, and also to manufacturers of watches, jewellery, &c., and to those persons they sent daily supplies of gold and silver, either fine or alloyed. The firm had a manufactory in Hatton Garden for melting and refining, which was the chief branch of their business. They undertook contracts for supplying the alloy bars required for coinage in Canada and various Foreign States. There was scarcely a carrying train in the day that did not convey bullion in some form. Platinum was one of the precious metals which was not in the Act of Parliament, and the railway companies would be liable for losses of any parcels of that metal. The firm dealt largely in that article. The amount of insurance done by the firm was very small, owing to the heavy rates charged. The insurance from London to Birmingham was 3*s.* for £50, or 6*s.* per cent.—a sum which very few of their customers would pay. The sendings of the firm in the ordinary trade business were from £3,000 to £10,000 a day, but these did not include the larger transactions, such as bullion sent to Birmingham to be coined, and bullion sent to Liverpool for shipment—consignments that often amounted to £50,000 per day. His firm had never sustained a loss in the shape of a large consignment, but had had losses in small parcels. Witness was of opinion that the charge for insurance should not be more than 3*d.* per £100, which would remunerate the companies, and would, he believed, be readily paid by the trade. He would make the insurance he spoke of compulsory.

The Committee also sat on Monday, 24th May, when Mr. Allport, manager of the Midland Railway, who was examined, said the articles mentioned in the Carriers' Act, supplemented by some others, should, in his opinion, if the companies were to be liable in case of loss or damage, be sent by passenger train, and divided into two classes for separate rates of insurance, clocks being included in the lower, and watches and jewellery in the higher class; he thought the distance should be taken into consideration in fixing the rate of insurance, and suggested that one rate of insurance, in each class, should be adopted for distances under 200 miles, and a higher rate above that distance, because it generally happened that places more than 200 miles distant were reached by more than one line of railway; a fair rate would be 1*s.* under, and 1*s.* 6*d.* over the 200 miles for articles in the lower class, and 2*s.* and 3*s.* in the higher class. The insurance should be compulsory, and the companies have the power to make some special arrangement in the case of any one parcel declared to be over the value of £500. He certainly considered the companies should have the power of inspection, unless Parliament relieved them from liability if they delivered a sealed packet intact. This power he only desired as a safeguard in case of suspected fraud.

A NEW PORTABLE BLOW-PIPE.

(*From the "Society of Arts Journal."*)

SIR,—As it is often very difficult to obtain a mechanical blow-pipe where gas is not to be had, I beg to describe the following apparatus, which I have found to answer every purpose, and which, as far as I am aware, is an original idea. Pass a stream of compressed atmospheric air through "benzole," using a Wolfe's bottle with two tubes for the purpose of applying the blast. The light of a spirit-lamp should be placed at the mouth of the other tube, when the current of air will become ignited, and will furnish a steady reducing flame of eight inches in length; the intensity and strength of the blast depending upon the amount of pressure applied. The chief advantage of this instrument is that, of course, it can be used whenever there is any atmospheric air to pass through the benzole, which spirit scarcely suffers any loss, even after some hours' use.—I am, &c.,

JAMES LEATHERBARROW.

ON AN IMPROVED METHOD OF CONSTRUCTING THE DEAD ESCAPEMENT IN CLOCKS.

BY BENJAMIN LEWIS VULLIAMY.

(*Continued from page* 119, VOL. XVII.)

SUCH pallets are represented, Figs. 2 and 3, Plate V., applied to similar wheels, taking over the same number of teeth, and acting on the same centres as in Figs. 2 and 3, Plate IV. These pallets will be led an equal angle by the action of the wheel on each pallet, and lead the pendulum an angle equal to the angle it is led with the centres of action of the pallets in its proper place, as in Fig. 1, Plate IV.

This effect is produced in Fig. 2, Plate V., by increasing the angle of lead of the pallet, A A, and diminishing that of the pallet, B B; and it will be observed that though the two angles, B I C and D I E, the angles the pallets are led are equal to one another, and consequently that the pendulum will be led an equal angle by the action of the wheel on each pallet; yet that the angle, A I C of lead as drawn of the pallet, A A, is greater than the angle, B I C, the pendulum is led by the angle, A I B, representing the difference between the two; and the angle D I F, of lead as drawn of the pallet, B B, is less than the angle, D I E, the pendulum is led by the angle, F I E, the difference between the two. Consequently the total difference between the angles of lead as drawn is an angle equal to the two angles, A I B and F I E.

A similar remark applies to Fig. 3, with this difference, that the same effects take place on the reverse pallets; the angle of lead of the pallet A A is diminished, and that of the pallet B B increased; the angles, B I C and D I E, the pallets are led by the wheel, as in the former case, are equal to one another; but the angle, A I C, of lead of the pallet, A A, is less than the angle, B I C, the pendulum is led by the angle, A I B; and the angle, D I F, of lead of the pallet, B B, is greater than the angle, D I E, the pendulum is led by the angle, F I E; and the difference between the two angles of lead as drawn is an angle equal to the two angles, A I B and F I E. This alteration of the shape of the pallets requires a corresponding alteration in the shape of the teeth of the wheel, which must be longer and more undercut, and consequently weaker than when the centre of motion is determined, as shown by Fig. 1, Plate IV.*

It now remains to point out the difference between the pallets, as drawn Fig. 1, Plate IV., and Figs. 2 and 3, plate V. In Fig. 1, Plate IV., the angle of lead of the pallets as drawn and the angles they are led, are one and the same, and equal to one another, and consequently the pendulum is led an angle equal to either of these angles by the action of the wheel on each pallet. In Figs. 2 and 3, Plate V., this is not the case, it is true; the pendulum is led an equal angle by the action of the wheel upon each pallet, the angles, B I C and D I E, Figs. 2 and 3, Plate V., being in each figure equal to each other, but the angles, A I C and D I F, of lead of the

* In the case of the centre being placed as in Figs. 2 and 3, Plate V., and the angle of lead of the pallets supposed to be originally drawn as represented Fig. 1, Plate IV., the escapement will yet perform, and the pallets lead an equal angle to one another by the action of the wheel on each pallet by only altering the angle of lead of one of the pallets, as originally drawn. This is shown, Fig. 1, Plate V., where the centre of the wheel and pallets are placed, and all the parts, the angles of lead of the pallets excepted, are drawn as in Fig. 2, Plate V.; the angle of lead of the pallet, A A, is drawn the same as in Fig. 1, Plate IV.; but the angle of lead of the pallet, B B, is diminished to an angle sufficiently small to be led by the wheel an angle equal to the angle the pallet A A is led with its angle drawn similar to Fig. 1, Plate IV., and the two centres placed as in Fig. 2, Plate V.

In this figure, see Fig. 1, Plate V., the angles the pallets are led, and consequently the pendulum, though equal to one another, are less than in Figs. 2 and 3, same Plate, where they are purposely made to lead angles equal to the angle led, Fig. 1, Plate IV., at the same time they are led angles equal to one another.

If, instead of the angle of lead of the pallet, A A, Fig. 1, Plate V., being drawn, as in Fig. 1, Plate IV., the angle of lead of the pallet, B B, had been so drawn the angle of the pallet, A A, might equally be altered to suit the action of the pallet, B B, and similar effects would result as to the difference between the angles of lead of the pallets as drawn, and the angles led by the action of the wheel on the pallets; and consequently the angle the pendulum would be led would be considerably greater than in Fig. 1, Plate IV., instead of less, as in Fig. 1, Plate V.

s, are of necessity to enable the escape- to perform, drawn different from each , and different from the angle the ılum is led, the one being greater and ther less than the angle. The conse- e of this is that the length of the ed planes of the pallets is also very ent, the one being much longer than her, which renders the fraction upon vo unequal, and probably in the same as the difference in their lengths, and quently the impulse received by the s must, from that cause, independent of ther, be unequal. That this is an evil first magnitude in the dead escape- it would be a waste of time to astrate; it is only sufficient to observe the impulses received by the pallets unequal, the lengths of the arcs of ion of the pendulum will be unequal, consequently, performed in unequal .*

angles, A I B and F I E, Figs. 2 and 3, V., in each figure being equal to each it will be found in all cases that the of the angle led by one pallet above gle of lead of the same pallet as drawn e equal to the excess of the angle of over and above the angle led by the pallet.

posing the distance between the centres on of the pallets and the scape-wheel, ined as above described, see Fig. 1, IV, and lines drawn from the points the teeth of the wheel act upon the f the pallets to the centres of motion wheel and the pallets, they will form e an obtuse and the other an acute and both angles will differ an equal ty, half the thickness of the pallet right angle. Now, in principle, the advantageous point of action for the upon the rests of the pallets is at right to the two centres of motion; but as possible that the points of action on o rests should form right angles with the centres (for were the one a right angle, the other would be the thickness of a pallet greater or less than a right angle) it follows that the best construction is that in which the action of the teeth of the wheel on both rests differs the least possible quantity from a right angle, and is that which will have the least tendency to wear, and, as observed by M. Berthoud, No. 1325, "the most favourable possible."

There is a construction of the dead escapement, in which the point of action of the wheel upon the rests may be at right angles to the centres on both pallets, and, consequently, the rests at equal distances from the centre of motion of the pallets; but in that case the impulse upon the two pallets is not at an equal distance from their centre, but the thickness of a pallet further from the centre upon one pallet than upon the other. (See Fig. 2, Plate III.) The impulse upon the inclined planes of the pallets being at an unequal distance from their centre is a most serious defect, and the cause that this construction of pallets is no longer employed.*

Another advantage resulting from the mode of placing the centre of action of the pallets as above proposed is that the wheel will require to be undercut the least possible quantity; for if the centre of action of the pallet is raised above its proper centre of motion, it will cause the wheel to be more undercut than it need otherwise have been to free the pallet upon the inner rest on which the wheel acts, otherwise the point of intersection of the inclined plane and rest of the pallet will cause the wheel to recoil, by coming into contact with the face of the tooth of the wheel; and if the centre of the pallets is brought lower than the proper centre of motion, it will cause the wheel to be more undercut to free the pallet upon the outer rest on which the wheel acts, otherwise the action of that rest will occasion the wheel to recoil (though the effect is very much less considerable in this case than in the former); consequently, the proper centre of motion of the pallets is the most advantageous to the shape of the teeth of the wheel; for, as has been before noticed, the less the teeth of the

s is correctly true in the case of the pendu- ng supposed a beam and vibrating a short or in the case of a pendulum with a very b suspended on a knife edge, as many of the ks were made; but in practice, in the case of s' pendulum, and still more, a two seconds' m, and a heavy bob, the power of gravity y nearly overcome the difference in the ; nevertheless, the inequality of the impulse a certain degree, be prejudicial, particularly ry accurate performance is required.

case of the anchor escapement, as applied es, the evil would probably be greater and lt, and cause the arcs of vibration of the o be v.ry unequal.

* It has been before noticed that I. A. Le Paute, in his *Traité d'Horologerie*, 4to, Paris, 1767, page 168, mentions that Mr. Graham made his dead escapement for clocks with the rests at equal distance from the centre of motion of the pallets, and has so represented them in the plates to his work.

I do not recollect ever having seen a clock of Mr. Graham's with the pallet made in this manner, though I have seen such applied in old clocks.

wheel are undercut, the shorter, and, consequently, the stronger, they will be. It may be further observed, supposing the centre of the pallets to be in its proper place, that the greater the number of the teeth of the wheel the pallets take over, the less the teeth of the wheel require to be undercut. It must not be concluded from this that the number of teeth the pallets take over can be too great, for I believe the contrary to be the case, inasmuch as it is more advantageous in practice to communicate the impulse to the pallets at a moderate distance from their centre of motion, which will be the case when they take over six, seven, or eight teeth, than at a very considerable distance, as in the case when they take over eleven, twelve, or thirteen teeth.

To conclude: the great advantage of the mode of determining the distance between the centres of the wheel and pallets, and laying down the lines of the escapement, as above described, consists not only in enabling the escapement to be made with the least possible drop, and, consequently, with the least loss of power, and with the action of the wheel and the friction upon each pallet as equal as it can be in the dead escapement made according to the usual construction with the wheel between the pallets, but on its being of general application, and equally correct, whatever may be the size of the wheel, the number of its teeth, or the number of teeth the pallets are made to take over.

In the above, the drop of the escapement has only been mentioned incidentally, and no allowance made for that part of the action of the escapement which, by clockmakers, is termed the drop, or beat. In the dead escapement, in common with all other escapements, the drop is an unavoidable evil; and it is sufficient to observe that the more correctly in principle and accurately in execution the escapement is made, the less will be the quantity of drop requisite, and, consequently, the less the quantity of power lost.

The following observations have arisen out of the preceding pages, and, although not immediately relating to the subject of this paper, are, from the relation they bear to the construction of the dead-escapement, here inserted:—

It has been observed (see note, page 3, and Fig. 4, Plate III.) that the quantity of the angle of lead of the escapement depends upon two things,—the angle of the inclined planes, and the number of teeth of the wheel the pallets take over; and that the escapement may be constructed to lead the pendulum an equal quantity, with the pallets made to take over a few teeth, and with a low angle of lead; or with the pallets made to take over a greater number of teeth, and with a high angle of lead. It may further be noticed that the lower the angle of the inclined planes the less will be the friction upon them, and, consequently, the easier the action of the wheel upon the pallets; because the lower the angle the shorter the inclined planes, and, on the contrary, the higher the angle and the lower the inclined planes, the greater the friction, and the more unfavourable the action of the wheel on the pallets. At the same time it is to be observed that the less the friction on the inclined planes, the greater the friction on the rest. Supposing the case of two dead-escapements, similar in every respect except the angle of lead, of which the pendulums are made to vibrate equal angles (here the angle of vibration must not be confounded with the angle of lead), and the pallets of the one constructed with a low angle of lead taking over a few teeth, and the pallets of the other with a high angle and taking over a greater number of teeth, there will, in the first case, be less friction on the inclined planes and more on the rests; and, the second, more friction on the inclined planes and less on the rests; and, consequently, in the case of the pallets with a low angle of lead of the total space of time which is occupied by each vibration of the pendulum, a less portion will be engaged during the advance of the wheel and the giving the impulse, than during the action of the wheel on the rests of the pallets; whereas, in the case of the pallets made with a high angle of lead, the direct contrary will occur, unless, indeed—which is a possible case—the angle of lead should lead the pendulum exactly half the angle of vibration, when the portion of time the wheel is engaged on the inclined planes will be equal to that it is engaged on the rest of the pallets. This observation is made on the supposition that the whole vibration of the pendulum is made with equal velocity, which is not the case; but as the pendulum is acted upon by the clock through the inclined planes of the pallets, both during its ascent and descent, in the arc of vibration, I do not apprehend the distinction to be very material. Now, as all irregularities resulting from the train of wheels must be more felt during the period the impulse is being given, than during the period of rest, it follows that, on

Fig. 1, Plate V.

Fig. 2, Plate V.

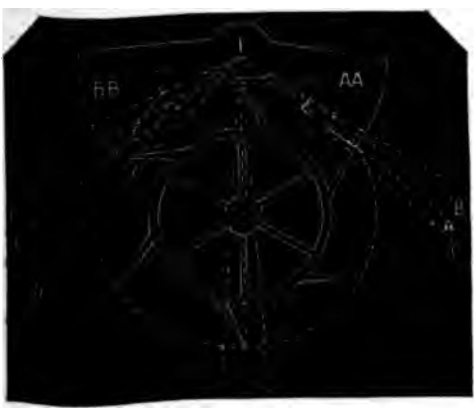


Fig. 3, Plate V.

that account, a low (or short) angle of lead is much preferable to a high one.

It is also worthy of notice that, in the case supposed above, of two pendulums made to vibrate equal angles by the action of dead-escapements similar, except in the quantity of the angle of lead, the pendulum applied to the pallets with the high angle will be much more liable to come to rest than the other, on account of the excess of the angle of vibration over and above the angle of lead being less than in the case of the pallets with a low angle of lead.

In a former paper, I described a new mode of constructing the pallets and their parts, by which great accuracy in the execution of the escapement is obtained. It might appear requisite that I should, to complete the description of the dead-escapement, decribe the method of dividing and cutting the teeth of the scape-wheel. But the subject of dividing and cutting wheels has been so fully entered into, and so much has been written on the subject,—and much to the purpose by various authors who have written on clocks and watches,—that it is quite superfluous to add anything further on the subject.

Letters to the Editor.

All Letters to be addressed to the Editor, at the Institute, 35, Northampton Square, E.C.

DRUM TIMEPIECES.

SIR,—As several persons have lately recommended different plans for improving the going of French drum timepieces, I beg leave to submit a plan I have recently adopted.

The great fault seems to be the pendulum not swinging far enough to allow the wheel to escape when the movement is nearly down; therefore, if the pendulum can be made to move with less friction on the pivots, it must go easier; and to accomplish this, take off the pendulum-rod, and on the end of the pallet-arbour fit a crutch made of fine watch pin-wire, by bending about four coils round a wire a little smaller than the pallet-arbour, and then driving this part on tight where the pendulum-rod came off; bend the other part into the shape of a crutch, like a Dutch clock, but not above ½ inch long, for lightness.

Drill a hole through the cock as close up under the pallet-arbour hole as possible, and

insert a brass pin, to serve as a stud to hang the pendulum on by means of a small piece of fine silk passed through two holes in the stud; in some cases both these holes must be on the under side of the cock, or sometimes both outside, and sometimes one outside and one inside, to allow the pendulum to hang clear of the squares, &c., at back, and just clear of back of the case. This is the most difficult part to get right. File a part of pendulum-rod flat, to prevent it turning round in the crutch, and file the top round and slight, and make a hook on the end to hang it by, and it is done. It increases the arc of vibration very much, and is very little trouble; it can be done without even taking the movement to pieces, except the pallets.

For a clock with silk suspension, I always set the holes a little askew, so that the silk shall be sure to press tight against one side of the hole by the mere weight of the pendulum.

J. VIRGO.

Sundridge, Sevenoaks.

STANDING *versus* SITTING.

SIR,—Will you allow me, through the *Horological Journal*, to draw the attention of watchmakers to the great advantage and comfort of standing up to work instead of the almost universal practice of sitting. I need scarcely point out how tiring and fatiguing is the position of sitting for eight or ten hours a day, bending chest or back over the board, especially to finishers and workmen in regular workshops, where there is no opportunity of moving about. Suffering from this tired feeling at the chest, I observed that a friend of mine had his board raised, so as to stand at work, and made the alteration for myself to my greatly increased comfort and health. Without trying the standing position, many would be inclined to doubt its steadiness for turning and general control over the work; but it is remarkable in how short a time one gets used to it, and in no instance have I found any disadvantage through standing to work. Although I provided myself with a high chair, I have never had occasion to use it. The sense of weariness I used to experience has entirely disappeared, and I strongly urge all workmen to try and judge.

I am, &c.,
A. D.

35, Goswell Road, E.C.

To Correspondents.

We have received from MR. HENRY A. NORMAN, *of Baltimore, U.S.A., in reply to* APPRENTICE'S *inquiry, the translation of Saunier's Mode of drawing the duplex escapement, as given by* W. C. *in the April number of the* JOURNAL. *We look forward with interest to further contributions from* MR. NORMAN.

MR. KNUDSEN *has favoured us, for publication, with some interesting letters on the Compensation Error, written to him by Mr. C. Reilly, who will be remembered as a former contributor in this* JOURNAL. *They will appear in next month's issue.*

HOROS.—*The caliper of a watch has reference to the wheels, pinions, &c., and their arrangement within the frames.*

Will any reader of your JOURNAL *kindly inform me how to bleach a silver dial.*—S.D.

Obituary.

DIED, at his residence in the Offord Road, on Sunday, the 24th of April, aged 68, Mr. William Farmer, many years editor of the *Clerkenwell News*, and the first honorary member of the Horological Institute—a distinction he well earned by the most devoted attention to the laborious duties attendant on committee-work, during the formation of the Society. In fact, so great was his zeal, and so accurate were his reports in the papers of that day, that he may well be considered one of the first promoters of the Institute.

He was, by profession, a short-hand writer, and, in his art, unsurpassed for skill and rapidity, and gave up a lucrative practice in the Law Courts to follow the fortunes of the Corn-Law League, whose whole career he reported until the close of that successful combination.

He subsequently settled in Clerkenwell, and soon made himself acquainted with the manufacturers and their wants, and consequently was quick to appreciate the importance of an Institute devoted to the cultivation of the sciences involved in the staple trades of Clerkenwell.

Although of late years Mr. Farmer did not reside in Clerkenwell, he kept up his acquaintance with a very large circle of friends, and was honorary secretary to the Clerkenwell Club from the time of its formation to the day of his death.

He was buried at Colney Hatch Cemetery, on the 29th of April, and the funeral service was performed in a most impressive manner over his remains by his favourite minister, the Rev. Henry Allan.

British Horological Institute.

VISIT TO THE BRITISH TELEGRAPH MANUFACTORY.

BY permission of Mr. ROBERT SABINE, a party of the members visited the British Telegraph Manufactory, in the Euston Road, on Wednesday, 16th June, for the purpose of inspecting Sir Charles Wheatstone's system of magneto-electric clocks and other instruments connected with electricity, which are there produced. The desirability of keeping the whole of the clocks in large public buildings, manufactories, &c., at work synchronously has led to numberless attempts to ensure that end by electrical connection, with more or less of success. In Sir Charles Wheatstone's arrangement, which we are about to describe, the maintaining power is supplied by magneto-electric currents, developed in a coil of wire, which is made to oscillate over the poles of permanent magnets. Each indicating clock is actuated by an astatic system of magnetic needles kept in continued rotation by these magneto-electric currents, and the motion of these needles is communicated through a suitable train to the hands. In this way the whole wire circuit remains unbroken, and the currents are alternately inverted without any making or re-making of contacts (one of the chief sources of failure of the electric system) being employed.

Sixty or seventy clocks or indicators may be actuated by one motor, although, on the occasion of our recent visit, but four or five secondary clocks in the building, and one at Sir Charles Wheatstone's house, about half a mile away, were connected with the driver.

Fig. 1 is a front elevation of the motor, or driving clock, which consists of a strong clockwork movement, supported by the iron frame, A A, and maintained by the weight, W. The escapement of this clockwork moves the pendulum, P, the "bob" of which (a coil of fine insulated copper wire) passes at each beat over the poles of two curved permanent magnets, M M. When this motor is regulated by a standard or astronomical clock, the regulation is effected by raising or lowering the centre of gravity of the pendulum, P, by means of a ball kept swinging with the pendulum, and the position of which is altered by the end of a lever, which, when released, falls upon the incline of a notch in the disc, B, which rotates once in two hours.

This lever is trigged, or set, once in every revolution of the disc, B, and is released at alternate hours by the electro-magnet, E, attracting its armature. If the clock is

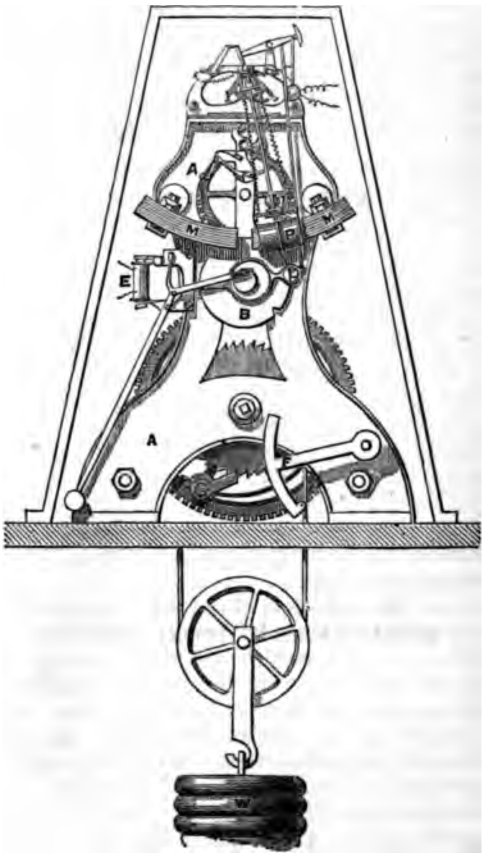


Fig. 1.

keeping accurate time the lever falls, when the current arrives, into the middle of the notch. If it is going too slow it falls on the upper incline of the notch, and thereby raises the secondary pendulum; if too fast it falls, on the lower incline of the notch, and lowers the pendulum correspondingly. In this way

the rate of the clock is adjusted every two hours.

Fig. 2 shows the arrangement by which the regulating hourly current is given by a standard clock. The pin, P, on the wheel, M, raises the shorter arm of a bell-crank lever, which carries a weight, W, and is arranged so as to release it exactly at the hour when the lever swings and makes contact with the end, C, of the spring, S, thereby closing the circuit of a battery attached to the screw, *e*, of the block, E, and of the electro-magnet shown in Fig. 1.

The ordinary dead-beat escapement was found to be unsuitable for the driving clock, because of the excessive weight found necessary. The escapement eventually adopted deserves attention. The pallets are segments of circles, and roll upon the teeth of the escape wheel; but as a drawing is necessary to properly convey its construction and

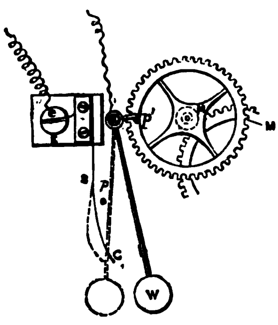


Fig. 2.

action, we shall refer to it more fully on another occasion.

As the wire bob of the pendulum of the motor clock swings backwards and forwards (beating half-seconds) over the similar poles of the two permanent magnets, M M, alternate, positive, and negative currents are induced in it. These currents circulate in the wire coils of the secondary clocks, which are in the same circuit, and actuate their mechanism. The internal mechanism of the secondary clocks is shown in Fig. 3. It consists of a coil of wire, G, with an astatic system of needles, N, *n s*, *n s*, on the axis of which is a pinion, P, gearing into the train, C M, which moves the hands, H and *h*. The wire of the coil, G, is connected, by means of insulated wires, with the coil of the pendulum-bob, P, in an unbroken metallic circuit.

It is found necessary to employ control currents to regulate these motor clocks, which would otherwise vary considerably with change of temperature, causing variation in the magnets, M M, and therefore of the resistance to motion of the wire coil of the pendulum. When left uncontrolled it is found that a lower temperature would cause the motor to go slower, whilst a higher temperature would cause it to go faster—the reverse of the effect due to elongation.

The sudden addition to or subtraction of

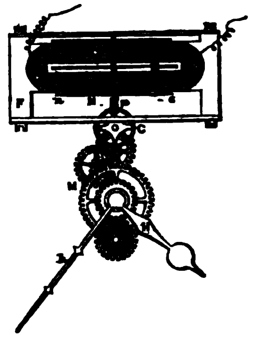


Fig. 3.

secondary clocks from the circuit also causes a temporary variation of the rate of the driver. The addition of secondary clocks to the circuit, by lessening the current in the circuit, causes the driver pendulum to oscillate faster; the subtraction of secondary clocks causes it to beat slower. When the system is controlled by periodical currents, any sudden change of temperature or resistance is quickly compensated, but it is for a few hours traceable.

For instance, in a circuit in which 20 secondary clocks are driven, and which was varying 1 or 2 seconds per day, on the subtraction of 4 of the clocks, the controlled driver lost 10 seconds in the following 24 hours, but recovered them during the next following day.

The members were much indebted to Mr. Sabine for the pains he took to make the visit interesting, and for his explanation of the various objects submitted. Next in interest after the magnetic clocks appeared to be the optical, or polar, clock of Sir Charles Wheatstone, of which we hope to get a full description from the distinguished inventor. A large dial was exhibited—a copy of that in use at St. Stephen's Club. A hand upon the dial points to whatever order of the day is engaging the attention of the House, for the information of members who may be in the club. Specimens of nearly all the transmittors and indicators in use were also shown, and examined with evident interest by the members, after which, by means of a powerful voltaic battery, a very brilliant electric light was generated between charcoal points.

ABSTRACT OF THE REPORT OF THE ASTRONOMER-ROYAL

To the Board of Visitors of the Royal Observatory, Greenwich, Read at the Annual Visitation of the Royal Observatory, 1875, June 5.

BUILDINGS AND GROUNDS.

For the service of the clock movement of the great equatoreal, as will be hereafter explained, a water-cistern has been established in the highest part of the ball-turret, and is supplied with water by ordinary ball-service from the Kent Water Works. The height of the cistern from the ground exceeds 40 feet, but the pressure of water in the supply pipes at the ground-level is about 100 feet, and there is, therefore, no difficulty of supply. Care has been taken to increase the protection against frost, and to give means of emptying the cistern. As the rising supply-pipe passes close to the door of the octagon room, a hose has been laterally attached which can discharge water into the room.

MOVABLE PROPERTY.

Our movable property of general character is in its usual good state, and requires no special notice. A portrait of Graham has, by the kindness of Dr. Henry Lonsdale, of Carlisle, been added to the collection in the octagon room.

For observation of the transit of Venus, there were issued from the Observatory (besides various instruments constructed for the transit, and considered to belong to the Observatory, though not yet borne on its catalogue), the large portable altazimuth with axial view, and several telescopes. The altazimuth has been received, but has not at the time of my writing been examined; the telescopes are not yet received.

ASTRONOMICAL INSTRUMENTS.

The transit-circle is in good working order, and has required very little attention during the past year. As regards observations of R.A., it demands no further remark.

The correction of $+0^{r}\cdot019$ or $+0''\cdot28$ has been applied to the readings for coincidence of the nearly vertical wire of the north collimator with that of the south collimator, when taken through the pierced cube of the transit-circle, as explained in the last report.

No new determination of the coefficient of flexure has been made since the date of the last report.

A new and stronger recording-apparatus has been applied to the zenith-distance-micrometer; that first made having been injured by a blow.

From 1875, January 1, the circle-reading for the nadir-point observation has been taken with the circle-reading $179^\circ.\ 35'. + 3^{rev.}$ (approximately), instead of $179^\circ.40'. + 0^{rev.}$ (approximately); which brings the image of the wire more nearly into the centre of the field of the telescope, and the divisions of the circle more nearly into the middle of the field of the microscopes; the system previously used having made the observation largely dependent on the value of the telescope-micrometer-screw, and on the correction for runs, as referred to the centre of the field. When the change was made it was found that the discordance between the zenith-points deduced from the nadir-observation, and those obtained from the mean of north and south stars, changed from $-0''\cdot7$ to $+0''\cdot6$; an alteration of $1''\cdot3$. This result naturally threw doubt on the value of the telescope-micrometer-screw, but a careful redetermination of this gave a result almost identical with that previously found. As there appeared to be no probability of so large an error in the adopted division-errors of the circle, observations of the nadir-point were made with the same division in different parts of the field of the microscopes; and at the same time the runs of the screws were taken for readings at the zero and half a revolution on each side of it. In both cases considerable discordances were found, indicating an inequality in different parts of the threads of the micrometer-screws. It is suggested by Mr. Simms that this is probably the effect of wear; and this idea seems admissible, when we consider that the screws have been turned nearly one hundred thousand times, with more frequent bearing at the middle of run than at the ends. As a check on these results, observations of the nearly horizontal wire of the south collimator were made, in which the same interval of its micrometer-screw was measured in terms of the screws of the micrometer-microscopes at each revolution in the field of view. They are yet scarcely complete, but they seem to show clearly that the apparent measure of a definite arc varies according to the position in the microscopes' field of view, of the space traversed by the micrometer-wires; increasing from one side of the field to the other. It appears not improbable that we may be compelled to introduce new micrometer-screws.

It is to be remarked that the adopted zenith-points are free from systematic error, the nadir observation having been regularly

corrected for discordance, as found from the observations themselves, so that the result for zenith-point really depends on observations of stars alone which are distributed over the whole range of the micrometer-screws. But it is possible that the results for N. P. D. of special stars may require special corrections.

The adjustment of the apparatus for correcting the barometric inequality of the sidereal standard clock appears now to be complete; and the arc of vibration is very steady.

The chronograph is in good order, and it has not been found necessary to clean it during the past year.

The altazimuth is in excellent condition. The counterpoises of the horizontal axis were removed last October, and the instrument has been used since that date without them, the object being to insure the stability of that axis. To protect the supporting bars of the upper pivot from the radiation of the axis-lamp, which was found to produce a sensible effect on the position of the vertical axis, tin covers have been made for the iron rods forming the upper triangle. The value of the level-divisions was tested on November 20 by Mr. Simms' level-prover, the result being that the readings of the zenith-distance-levels require a correction of $+\frac{3}{40}$ to reduce them to seconds of arc, whilst those in azimuth are sensibly correct.

A new set of webs was inserted on August 21, and two others were subsequently renewed; the intervals were determined by transits of stars.

In order to determine the collimation-error independently of stars, the positions of the collimating-mark and lens have been altered, so as to produce a reversed telescope in a horizontal direction. For this purpose it has been necessary to raise the dome three inches, and view the mark through a hole in its curtain. The collimating-mark is to be fixed to the chimney of the upper computing-room. As this place is somewhat difficult of access, an apparatus, consisting of a galvanic battery and small induction-coil, whose spark will light the gas-lamp, is to be provided by Messrs. Comyn, Ching, and Co.

I have had it in contemplation to determine the error of level of the horizontal axis by use of a collimator passing downwards through the wall of the room, at an angle (approximately) of 45° with the vertical; but no step has yet been taken for carrying out this idea.

The Sheepshanks and Shuckburgh equatoreals are in their usual condition, and are available for observation of occultations and phenomena of Jupiter's satellites.

The great equatoreal is in a very satisfactory state. Various small alterations and additions have been made to it to adapt it to the spectroscopic and photographic work, for which it has chiefly been used during the past year. Amongst these may be mentioned a new dew-cap and cover to the object-glass, indexes to the slow-motion rods, a sliding counterpoise on the telescope to balance the spectroscope, a small photographic camera, a cupboard for chemicals, movable steps to the observing-chair, and a stage for observing objects near the pole, which was used for Coggia's Comet of last year.

Mention has already been made of the cistern in the ball-turret for supply of the water-clock, the necessity for which arose from the following circumstance:—The water-clock was supplied by a small pipe, about 80 feet in length, connected with the three-inch observatory main (which passes through the Park), at a distance of about 250 feet from any other branch pipe. In spite of this distance, I have seen that, on stopping the water-tap in the battery-basement under the north-east turret, the pressure in the gauge of the water-clock has been instantly increased by more than 40 lbs. per square inch. The consequent derangements of the water-clock in its now incessant daily use became intolerable. Since the independent supply was provided, its performance has been most satisfactory.

A movable weight has been adapted to the pendulum for changing readily from sidereal to mean solar time.

For photographing the moon, &c., I have sketched a slipping-piece to give a motion to the photographic slide in any desired direction and with any required speed, keeping the moon stationary on the plate. This apparatus has not yet been constructed.

The spectroscope has received some additions and alterations, which have been suggested by practical experience. Some trouble was at first experienced from false light, but this has now been entirely got rid of by suitable adjustment; and the only defect appears to be a want of coincidence between the foci in the two planes parallel and perpendicular to the slit, the surfaces of the prisms being all slightly cylindrical. This is a fault which exists in all spectroscopes of which I have been able to obtain information, and, though trifling in amount where small dispersive power is used, it becomes important with a large number of prisms (the errors being all in the same direction), and

interferes seriously with the definition of the solar prominences. Although a great improvement has been made by re-working the prisms, it has not yet been found practicable to get rid altogether of this defect; it has therefore been corrected by inserting a cylindrical lens in the collimator-telescope near the slit, a delicate adjustment being made by varying the distance of the lens from the slit.

The plan originally adopted, of comparing the spectra of stars with that of a vacuum tube placed in the course of the rays within the telescope, having been found to give unsatisfactory results, two comparison prisms have been fixed in front of the slit in connexion with a collimating lens, by which an image of the comparison-light is thrown on the slit immediately above and below that of the star, in such a way that the cone of rays from this image fills the whole object-glass, and is thus subject to identically the same conditions as the star's light.

A new micrometer has been made for the spectroscope by Messrs. Ladd and Hilger, that originally applied being a very old one, which was found to be defective. A small telescope has been adapted by Mr. Simms, by means of which the dispersion of a half compound prism can be used, giving a spectrum of 3½°, applicable to faint objects. For such cases also the original star-spectroscope made by Mr. Simms has been fitted with a slit, which permits the use of a comparison-spectrum.

Mr. Spottiswoode has kindly placed his powerful automatic spectroscope at my disposal during the adjustment of the Royal Observatory spectroscope, it being very desirable to have some standard of comparison by which to test our instrument.

A Sprengel air-pump has been made, with Mr. Crookes' friendly co-operation, by Mr. Hicks, of Hatton Garden, who has applied some improvements introduced recently by Mr. Crookes.

The reflex-zenith-tube is in a satisfactory condition.

The Kew photoheliograph is in an efficient state. A spiral spring has been adapted by Mr. Simms to the instantaneous slide, in place of caoutchouc, which gave much trouble from its breaking.

Instead of the Kew photoheliograph, I propose to mount the Transit-of-Venus-photoheliograph returned from Egypt, as soon as its optical distortion has been determined from photographs of Mr. De La Rue's scale.

An instrument has been prepared and brought into use for measure of the areas of the solar spots in the photoheliograms, by comparison with squares engraved on the field-plate. The photographic plate is placed above a mirror, by which the light of the sky is reflected to the eye.

ASTRONOMICAL OBSERVATIONS.

The moon every day, and the sun and large planets every week-day, have been subjects of regular observation on the meridian; the small planets have been observed, as usual, only in the first half of the lunation; having been, however, very rarely visible, in consequence of the cloudy state of the sky in the last winter and spring. (The observations of other objects have suffered in the last six months from the same cause.) The stars observed have been fundamental stars, and other stars described in the reports for 1872, 1873, 1874.

In order to eliminate (as far as practicable) systematic errors in the determination of positions of fundamental stars, the rule has been adopted, since the beginning of this year, of rejecting the R. A. of all clock-stars, as determined from observation, when the group does not extend over six hours at least; the more limited groups being used only for determining clock-error. At the same time, in order still further to link together stars differing in R. A. by twelve hours, the assiduous observation of pairs of circumpolar stars above and below the Pole has been continued on the system introduced in 1872.

Many of the stars in the old working catalogue having been sufficiently observed, a new one has been prepared, containing, in addition to the clock-stars, about 1,500 stars of which further observations are required. Many of these, however, require only a single observation. This list will probably last till the next general catalogue is formed, perhaps at the end of 1877.

A series of measures of cusps were made with the great equatoreal during the eclipse of the sun last October, from which the corrections to the moon's tabular R. A. and N. D. P. were found ; the corrections to the diameters of the sun and moon being assumed from the results of the eclipse of 1870, which was much more favourable for the determination of these elements.

SPECTROSCOPIC AND PHOTOGRAPHIC OBSERVATIONS.

With the spectroscope the solar prominences have been mapped on 28 days only ;

but the weather of the past winter was exceptionally unfavourable for this class of observation; and, before the appointment of a computer as photographic assistant, Mr. Maunder's time was much occupied with photography, so that the best hours of the day were sometimes lost. After mapping the prominences, as seen on the C line, the other lines, especially F and *b*, have been regularly examined, whenever practicable. Great care has been taken in determining the position, angle, and heights of the prominences in all cases. Hitherto there has not been much opportunity of examining sun-spots with the spectroscope, but a few observations of this kind have been made. At Prof. Clerk-Maxwell's request, some measures of the breadth of different Fraunhofer lines have been made, but nothing of value in this direction can be obtained unless the sun is high and the air very pure.

In all this work, the power of readily changing the number of prisms employed has been found very useful, as it is impossible to use high dispersive power with advantage when the sky is hazy.

The spectrum of Coggia's Comet was examined at every available opportunity last July, and compared directly with that of carbon dioxide, the bands of the two spectra being sensibly coincident. Decided polarisation in a plane passing through the sun was found in the coma as well as in the tail of this comet, a double-image-prism being used for this observation.

Chronometers, Time Signals, Regulation of External Clocks.

The number of chronometers now in the chronometer-room is 143, consisting of 133 box-chronometers, 3 pocket-chronometers, and 7 deck-watches. Of the box-chronometers, 49 are the property of chronometer-makers, who have placed them on the annual competitive trial; all the others are the property of the Government. The competing chronometers, and others which seem to require it, are compared with one of the sympathetic clocks of the mean-solar-standard-system every day; all others every week. Every chronometer undergoes trial, at least for one period of three weeks, at temperature approaching 95°; some are exposed for cold to the open air; but no artificial cold is ever used. All new chronometers are tried with the XII. hour N, E, S, and W.

The stock of chronometers is usually kept up by purchases of the best chronometers from the competitive trial, at premium-prices submitted by me to the Board of Admiralty. Sometimes chronometers are purchased, on trial, from Navy officers. On some few occasions (as the Chinese war) large numbers have been bought hastily; and in the spring of this year, 22 chronometers being demanded for the Arctic Expedition, 73 chronometers were immediately put on trial for selection of 22 to fill the place of those required.

One solar and one sidereal chronometer are now withdrawn from the general stock, for the service of the Observatory.

The error-numbers of the chronometers in the competitive trial of 1874 are somewhat greater than those of several years past. The difference, however, is small; about one-tenth part of the whole.

The interruptions in the daily drop of the Greenwich time-ball from high wind have been only 6 in number.

The Deal time-ball was not raised (on account of the violence of the wind) on 5 days; and was not dropped or was erroneously dropped on 7 days, from an omission of connection of the wires. On 45 days the current failed to release the trigger without assistance from the attendant, principally from a defect in the wire within the town of Deal, for which a new one has now been substituted. The ball tower at Deal has undergone some repairs.

The general system of time-signals, originating at this Observatory and disseminated by the Post-Office-Telegraph through the whole of England, and to Scotland and Ireland, was so fully described in my last report that I need not to enter into it further at this time. I shall only remark that the system continues to spread, and that it appears to be now a valuable national institution.

It has been explained in former reports that sidereal clocks in the Observatory (as far as necessary) are connected galvanically; that all the mean solar clocks are connected galvanically; and that, after due comparison of clocks of the two classes, all the latter are brought to accurate time by galvanic action on the pendulum of one. Advantage is taken of the same principle when any occasional wants arise; as for hourly signals to the Magnetic Observatory, signals at every second to one of the Transit-of-Venus huts, &c.

The Lombard Street clock has been maintained in all the accuracy that is required for post-office purposes, with scarcely a failure; and the Westminster clock has been so well regulated, under the check of automatic report to this Observatory, that on 83 per cent. of the days of the year its error is below one second.

Proposals have been made for galvanic determination of the longitude of the Dublin Observatory, and the operation is delayed only for convenience in the arrangements to be made in Dublin.

The principal galvanic operation of the year has been, however, that connected with the Egyptian stations for the transit of Venus. On the part external to England I shall speak hereafter; at present I allude only to the English part. By the assistance of the Post Office, uninterrupted metallic communication was made between this Observatory and the telegraph station of the Eastern Telegraph Company at Porth Curno, a small bay a few miles east of the Land's End. Mr. Ellis proceeded to this station, carrying proper chronometers, and signals were made to and from the Observatory, and were observed at both ends. On the same evenings, signals were passed between Porth Curno and Alexandria, and were observed at both stations. These two series of observations, though made by the same person at Porth Curno, and strictly part of the same system, were entirely independent; as, for the safety of the submarine wires, it is not considered prudent to connect them with open-air wires on land.

EXTRANEOUS WORK.

The first subject to which I have to advert is the observation of the transit of Venus.

The parties from Egypt (A) and Rodriguez (C) are returned, with their instruments, &c.; and the instruments, &c., are returned from New Zealand (D). I am in continual expectation of the arrival of the other parties.

With regard to Egypt, the first point to be insured was the determination of the longitude of some one station. The submarine telegraph is, for commercial use, broken up into several parts. I have had experience of the troubles incident to the use of a broken line, and I determined to rely on purely astronomical methods, unless we could transmit signals in an unbroken line from Cornwall to Alexandria. This was no easy matter; the line is longer by several hundred miles than any other submarine line which has been so used; and the wire, as I understand, is smaller in section than any other long wire. I cannot say how much I am indebted to the assistance of the Eastern Telegraph Company, of their officer at Porth Curno, and of C. F. Varley, Esq., who aided us with his counsel, and who lent us (for experiment) his great resistance-apparatus, imitating the effect of a submerged wire, and other apparatus. In the actual operation, Mr. Ellis at Porth Curno received signals from Greenwich and sent signals to Alexandria; Mr. Hunter received them at Alexandria, and sent signals to Captain Orde Browne's observatory on the Mokattam Hills above Cairo (to which the Khédive had constructed a telegraph for the use of the Expedition); and communication was thus made both ways between Greenwich and Mokattam on the same night. This was repeated four times. I shall not delay further than to remark that I believe the eye-observations and the ordinary photographs to be quite successful; that I doubt the advantage of the Janssen; that one of the double-image-micrometers (an old one, very ill made, in whose construction I had no part, and which I had not seen) seems to have failed; and that the zenith-telescope gives some trouble. The Suez station, I expect, will well connect us with the stations in the Indian and African seas.

At three stations at C, Rodriguez, and three at E, Kerguelen, the observations appear to have been most successful. At B, Sandwich Islands, two of the stations appear to have been perfectly successful (except that I fear that the Janssen has failed), and a rich series of lunar observations for longitude is obtained. At Rodriguez, besides our own lunar observations, we have good communication by chronometers with Lord Lindsay's stations. At Kerguelen I believe that the longitudes of the foreign stations will depend on ours. At D, New Zealand, I grieve to say, the observations were totally lost, entirely in consequence of bad weather. The arrangements made by Major Palmer for establishing his own stations, for organizing the whole country into an assembly of observers, and for removing every obstacle that could be foreseen, were most admirable, and might well be taken as a model for future operations. But in the whole length of the southern island not an observation was made, except an imperfect series by the American party at its southern extremity.

There has been little annoyance from the dreaded "black drop." Greater inconvenience and doubt have been caused by the unexpected luminous ring round Venus.

From mechanical or optical causes which Captain Abney has not yet overcome, we have not yet perfectly succeeded in the observations for examining photographic distortion.

Mr. Simms is preparing, under my direction, an instrument for measuring the distance of the centre of Venus upon the photographs from the centre of the sun.

The second matter is the progress of my proposed new lunar theory.

Basing my application upon the resolution of the Board of Visitors at their last meeting, I submitted to the Admiralty, and through them to the Treasury, a request for assistance in carrying on this work. After necessary explanation, the Treasury sanctioned the expenditure of a sufficient sum in the then current financial year, and permitted the insertion in the Navy estimates of a statement for grant to cover expenses during the present financial year. Three computers are now steadily employed on the work.

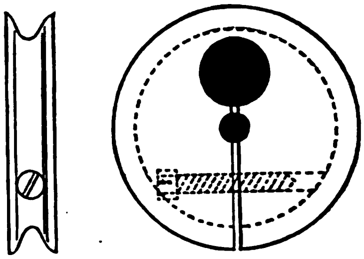
It will be remembered by the Visitors that the detail and mass of this work are purely numerical; every numerical coefficient being accompanied with a symbolical correction whose value will sometimes depend on the time, but in every case is ultimately to be obtained in a numerical form. Of these co-efficients, extracted (for convenience) from Delaunay's results, there are 100 for parallax, 182 for longitude, 142 for latitude; the arguments being preserved in the usual form. On the left side of the three equations all the raisings of powers, multiplications, and differentiations, are performed; using for the last unit 10^{-7}, and, where coefficients are diminished by differentiation, using a more advanced figure (this last operation not quite perfect at the present moment). On the right side or side of perturbing quantities the powers of the sun's distance, &c., are introduced, but the functions of angular distance between sun and moon are not formed. Of the symbolical corrections, which for the co-efficients are introduced step by step, nearly one-half are prepared; those for arguments (which are very much simpler) are not yet touched. The oblateness-terms admit of being treated almost independently, and I had myself advanced considerably with them, but a sudden influx of business compelled me to lay them aside, and I have not yet returned to them.

On Tuesday, July 20, the 17th annual general meeting of members of the British Horological Institute will take place. As will be seen by advertisement in this number, important vacancies have to be filled, and other business to be transacted, rendering the occasion one of particular interest.

On Tuesday, July 27, a party of the members will visit the Clock Factory of Messrs. Gillett and Bland, at Croydon.

AN ELASTIC FERULE.

The ferule I am about to describe is an improvement on one given in a series of articles in Saunier's "Manuel de Horologie," under the title of "Our Little Tools." It is made of brass, with one hole pierced in the centre, and another as near the edge as possible. The larger this latter is, the greater will be the flexibility of the ferule. It is cut open with a thin saw, as shown, and a screw fitted.



One great advantage is its narrowness, and, being made of brass, it will not injure or mark the staff or pinion to which it may be fixed. It will be found very handy for jobbing, or even in the first stages of pivoting. The centre hole may, of course, be made large enough to allow the body of a pinion to enter; but in this case the outer hole must be reduced in proportion.

A. DALDORPH.

The following statement made in 1865 by Mr. Varley, which has been handed to us by a correspondent, had reference to the time-ball at Charing Cross, which is now removed, but is none the less interesting, as most of the observations would apply to time-balls generally :—

"The exact time is telegraphed every hour from Greenwich, and as long as stellar observations can be had, every night; the time-ball is discharged at exactly 1 p.m., but if the weather is bad enough to interrupt the observations, error will ensue. The greatest error acknowledged by the Astronomer-Royal, from this cause, is $1\frac{1}{2}$ seconds, which is the greatest accumulated error arising from the longest interruption. A constant error of $\frac{1}{2}$ second arises owing to that time being lost in the working of the detent which discharges the ball and in the imperceptible motion of the ball before its descent becomes visible to the eye. A further interval of nearly $\frac{1}{2}$ second is due to the time taken up in the acknowledgment by the mind of what the eye sees, so that the time when the ball appears to begin its descent is nearly 1 second slow."

Letters to the Editor.

All Letters to be addressed to the Editor, at the Institute, 35, Northampton Square, E.C.

THE COMPENSATION ERROR.

SIR,—Some years ago I had the pleasure of getting acquainted with a gentleman who was a civil engineer, and at the time living in London. We had some conversations about chronometers, and several letters on the subject of the imperfections in the compensation for heat and cold passed between us. With one exception, I did not take copies of my own letters, and have forgotten what I wrote, but I believe we did not agree. I have, however, preserved the letters of my correspondent, and as they would most likely be just now read with interest by persons in the trade, I have sent them to you, if you like to publish them.

I am, &c.,
F. KNUDSEN.

24th May, 1875.

1, King's Bench Walk, Temple, E.C.,
16th May, 1866.

MR. KNUDSEN.—DEAR SIR,—You will perhaps remember some conversations we had on the subject of the compensation-balance some months ago, in which I quoted the dynamical law, which I had thought was universally accepted by all horologists, that the resistance of the balance to the elastic force of the spring varies directly as the *square* of the radius of gyration. This I understood you to deny, on the ground that, if it were true, the chronometer would *gain* in extremes of temperature if adjusted correctly for a mean range of temperature.

I promised that, as soon as I could find time for the purpose, I would send you a mathematical demonstration proving the contrary, namely, that the chronometer would *lose* in extremes (as it is well known in practice to do), solely in consequence of the law before mentioned. I have been too much occupied to turn my attention to this subject until recently, but I will now put the argument in as few words as I can.

For the sake of simplicity, it will be necessary to make three suppositions, neither of which are realised in any actual compensation-balance.

(A) *First*—That the *whole* weight of the balance is concentrated in the compensation weights which are movable to and from the axis by the expansion and contraction of the compound laminæ; the staff arms and rim must thus be, for the sake of argument, supposed to have *no* weight.

(B) *Secondly*—That all the compensation weights are merged into one single weight, and that the weight of that single one is concentrated in one physical point, viz., its centre of gravity.

(C) *Thirdly*—That this *theoretical* compensation weight (as it may be called) is moved by the action of the compound laminæ exactly in a straight line, and in the direction of the radius, and also by equal increments of distance for equal increments of temperature.

All these assumptions are favourable to your own conclusion,* because if I can satisfy you that, notwithstanding these assumptions, the law before mentioned makes the chronometer lose in extremes (instead of gaining, as you think it would), it will be easy to show that the real balance will lose still more in extreme heat, and will still lose in cold, but in a less degree.

Now, it is well known to you that the elastic force of the spring acting upon the balance varies inversely as the temperature, and therefore if the compensation were perfect for *all* temperatures (that is, if there were no secondary error), the resistance of the balance to the impelling force of the spring ought also to vary inversely as the temperature. The measure of that resistance is a well-known mathematical quantity called the "moment of inertia" of the revolving body, and is expressed either in units of *weight* or units of *mass*, whichever is most convenient for the problem in hand, the former being the most convenient for the present purpose.

On account of the first and second suppositions (A and B), the centre of gravity of the theoretical compensation weight is also the "centre of gyration" of the entire balance,† that is, of the entire revolving body which resists the force of the spring.

Now, the "moment of inertia" of any revolving body is its weight multiplied by the square of its "radius of gyration" (that is, the distance of its centre of gyration from the axis of rotation).

* By this I mean that the preceding suppositions would, if true, make the chronometer lose in extreme heat less than it really does in actual practice.

† The nature of the simplification acquired by means of those suppositions is evident from considering the fact that the position of the centre of gyration of any compensation weight, relative to the dimensions of that weight, changes with every change of radius produced by change of temperature.

Now, let us consider what changes in the amount of resistance to the force of the spring of this theoretical balance take place when the spring is subject to successive changes of temperature of *equal amount*, supposing that the chronometer is adjusted to mean time in mean temperature.

Let R = radius of gyration corresponding to a mean temperature T,

„ $\pm r = \begin{Bmatrix}\text{increase}\\\text{decrease}\end{Bmatrix}^*$ of R owing to $\begin{Bmatrix}\text{decrease}\\\text{increase}\end{Bmatrix}$ of T, and $\mp t$ equal that $\begin{Bmatrix}\text{decrease}\\\text{increase}\end{Bmatrix}$ of T.

Then when the temperature = T, the radius of gyration = R.

When the temperature is increased or diminished to $T \pm t$,

R is diminished or increased to $R \mp r$;

When T becomes $T \pm 2\,t$,

then R becomes $R \mp 2\,r$;

When T becomes $T \pm 3\,t$,

then R becomes $R \mp 3\,r$;

and so on for further equal increments of T and R.

Let W = the weight of the theoretical compensation weight (see B),

„ I = its moment of inertia for some mean temperature T,

„ I_1 = ditto for temperature $T \pm t$,

„ I_2 = ditto for temperature $T \pm 2t$,

„ I_3 ditto for temperature $T \pm 3t$,

„ I_4 = ditto for temperature $T \pm 4t$,

and so on for further equal increments of T.

$$\begin{aligned}
\text{Then } I &= W\,R^2,\\
I_1 &= W\,\{R \mp r\}^2\\
&= W\,\{R^2 \mp 2\,R\,r + r^2\}\\
I_2 &= W\,\{R \mp 2\,r\}^2\\
&= W\,\{R^2 \mp 4\,R\,r + 4\,r^2\}\\
I_3 &= W\,\{R \mp 3\,r\}^2\\
&= W\,\{R^2 \mp 6\,R\,r + 9\,r^2\}\\
I_4 &\quad W\,\{R \mp 4\,r\}^2\\
&= W\,\{R^2 \mp 8\,R\,r + 16\,r^2\}
\end{aligned}$$

* The + sign corresponds to "increase," the — sign to "decrease."

and so on for further equal increments of T and R.

Now, if we take the differences between I and I_1, I_1 and I_2, I_2 and I_3, and so on, we find that those differences increase, and the differences of these differences (to use a clumsy but easily understood expression) increase, as we advance from the mean towards either extreme of temperature, in proportion to the following numbers successively—

3, 5, 7, 9, 11, 13, &c., &c.

That is to say, the $\begin{Bmatrix}\text{decrease}\\\text{increase}\end{Bmatrix}$ of I for the second equal $\begin{Bmatrix}\text{increase}\\\text{decrease}\end{Bmatrix}$ of T is $\begin{Bmatrix}\text{less}\\\text{greater}\end{Bmatrix}$ than that for the first by the quantity $3\,W\,r^2$; also that for the third is $\begin{Bmatrix}\text{less}\\\text{greater}\end{Bmatrix}$ than that for the second by the quantity $5\,W\,r^2$; that for the fourth is $\begin{Bmatrix}\text{less}\\\text{greater}\end{Bmatrix}$ than that for the third by $7\,W\,r^2$; and so on.

Therefore, if the resistance of the balance is adjusted correctly for the first equal increment (whether increase or decrease) of temperature, it is too great for the second, still more too great for the third, still more for the fourth, &c., &c.

Hence the chronometer must lose in both extremes if adjusted correctly for a mean range of temperature, as it is well known in practice to do, and the preceding theory is shown to be consistent with the observed results of actual practice.

But you may now object that the preceding result is deduced from the consideration of a certain ideal balance, impossible to construct, depending upon the suppositions A, B, and C, page 2, and therefore inapplicable to the case of any actual balance. But it is easy to see that the actual balance will lose still more in heat than the theoretical one, but it will lose less in cold*; because the moment of inertia of the fixed parts of the balance remains nearly unaltered by the changes of temperature, and, moreover, the motion of the compensation weights is not exactly in the direction of the radius. The countervailing influence of the fixed parts of the balance is apparent in the experiments by Mr. R. Webster, published in the *Horological Journal* for last April.

If you have time and inclination to pursue this subject, I shall be delighted if you can

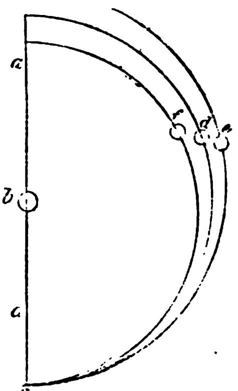
* But it will still lose in cold within the usual possible range of temperature, because the range within which the balance expands and contracts is only small, but this loss will be comparatively less than the loss in heat.

ι hole in my argument, and will, as ;unity may serve, give my best atten-ɔ any reply you may choose to put on

Yours very truly,

C. REILLY.

,—I was not very well at the time I ed your communication about com-;ion-balances, and it prevented me g your letter with proper attention ımplying with your request to state my ın on your arguments. I see, however, that you misunderstood me in what I led to prove. It had been stated to y several chronometer makers that ·es followed the same law as pendu- and that, in consequence of this, the ı of gyration of a balance required to ·ved four times further from the centre ·tion if a balance should be made to e as slow again, and that this was ause of chronometers going slower in ne than in middle temperatures. I stood you to be of the same opinion, ı was this I wanted to prove could not ·rrect, and that chronometers in that would go faster and not slower in ne temperatures. But as you are bly of the same opinion as myself on point, it will, perhaps, be unnecessary ıe here to prove it. I think it very ble that chronometers go slower in ne temperatures through the cause you ı to. I thought myself pretty well up chanical knowledge, but I have either known, or have forgotten, the law ed to, which law, I suppose, is in con-nce of an alteration in the centrifugal It is singular that in a revolving the effect should be quite the reverse a pendulum. For we find a half-ds' pendulum requires to be 9¾ inch ; a ds', 39 ; a second-and-a-half, 90 ; and ·-seconds' pendulum, 156 inches long ; ·as, in a balance the distance between ·ntre of gyration and centre of motion increase, but in a decreasing propor- if we shall obtain equal increasement ıe duration of the vibrations. The ·nsation of a chronometer, however, be affected by other causes as well as ɜ dynamical law. For if it were alone nsequence of this law the effect, I hend, would always be alike. But I seen some chronometers with ordinary ·nsation-balances go only about 2 ds per day slower in 32° and in 100° ·n 66°, and others where the difference mounted to as much as 5 or 6 seconds ·y ; and this has not appeared to be in ·quence of any particulary size or weight of the balances employed. It is not unlikely that some balance-springs by changes in temperature may warp a little from their shape in middle temperature, whereby the pivot friction on the balance pivots may get increased in extreme temperatures, and that this may retard the vibrations. But, if it should not originate from this cause, it may be that some balances bend with greater regularity than others, through a difference in the metals of which the rims are composed. There is also another thing which may affect the compensation. If the line *a a* represents the arms of a balance, *b* the centre, and *c d* one of the compensation rims, standing circular with the centre in a middle temperature of 66°, and we suppose that rim, by a change in temperature of a certain number of degrees below middle temperature, moved out to *e*, it would, in the same number of degrees above middle temperature move in to *f*, for *c e* and *c f* are of the same length as *c d* when measured along the lines, and are part of circles, of which one is as much larger as the other is smaller than the circumference of the balance in middle temperature; and when we now measure the distance from the centre *b* to *f d* and *e*, we



find that a compensation weight placed on the rim, in moving from *d* to *f*, must move through a greater space and approach the centre of the balance in a greater ratio than in moving from *e* to *d*; and it appears, therefore, if the rims bend with regularity, an ordinary compensation-balance must act more in temperatures that are above than below middle temperature, and that this increases by a long action of the rims. I believe balances on the flat principle must be the best. For as metals do not bend by changes in temperature, but only expand and contract, to the free expansion of the brass part of the rims, from which the moving power emanates, must be opposed a resistance equal to the force required for displacing the particles in the metals from their natural positions; and as the displacement must be greater in bending into a smaller than out to a larger circle, the resistance will also be greater, and the balance may from that cause act less in high than in low temperatures.

I am, Sir, yours, &c.,

F. KNUDSEN.

1, King's Bench Walk, Temple, E.C.,
August 4th, 1866.

DEAR SIR,—I only received your letter, dated 25th ult., yesterday. I am at present too much occupied by important matters to give that attention to the subject which it requires. As far as I have been able to see from one perusal of your letter, there are some things in it with which I agree, others in which I differ from you.

There is really a complete analogy between the action of the pendulum and the compensation-balance, although the calculations assume a somewhat different appearance; and, moreover, centrifugal force is not the cause of the peculiar action of the compensation-balance, although that force acts in certain ways upon both the pendulum and the balance. I will, sometime when I have more leisure, write to you fully on this subject, and I shall be very happy to continue the discussion of these points with you; they are interesting to both of us, and we shall both learn from it knowledge that it is useful and pleasant to possess.

If you think my letter worth publishing, you are quite welcome to send it to the *Horological Journal*. You will no doubt give the writer's name, and a short explanation of the circumstances which caused the letter to be written.

With thanks for your explanations,
I remain, yours truly,
Mr. F. KNUDSEN. C. REILLY.

1, King's Bench Walk, Temple, E.C.,
August 10th, 1866.

MR. KNUDSEN.—DEAR SIR,—I am favoured with yours of the 9th inst., and in reply I hope you will allow me to remark that you have taken me up rather sharply about the subject of pendulums, seeing that my note of last week was merely an acknowledgment of the receipt of yours dated July 25th, and contained a promise that, as soon as my leisure would permit, I would write you fully on the subjects touched upon in your own letter. It was no reply to yours, merely a promise that I would reply at the first opportunity.

I do not know what words I used in mentioning the subject of pendulums, as I did not keep a copy of the note; but you must bear in mind that our argument was on the subject of the compensation for temperature, nothing else; and what I intended to say was that the compensation of balances and of pendulums followed the same law, and that there was a complete analogy between them. And so I believe. But there is this difference between the calculations, that in the case of pendulums the third term on the right-hand side of the equation (which third term it is that explains the secondary error of chronometers) is so very small that it may be neglected, and accordingly it is cast out of the calculation. But the law itself is present all the same.

Now for a few words on the subject of the times of vibration of balances. What I remember to have said in conversation with you months ago on that subject was that the times of vibration of balances of different diameters but the same weight are in direct proportion to the squares of the radii of gyration, supposing them to be controlled by the same spring. And that I believe to be true. The general law is, *that the times of vibration vary as the moment of inertia of the balance directly and as the force of the spring inversely.*

You and I agree on this point, I believe, because the rough experiment with a piece of spring and a stick which you showed me some months ago is in accordance with the above theorem; but at the time I did not succeed in understanding what you intended it to represent.

To show the same thing mathematically, suppose we have a balance vibrating $\frac{1}{2}$ seconds, and of 1 inch radius; another balance to vibrate seconds, with the same spring, and, being the same weight as the first, must have twice the moment of inertia of the first. That is to say, if

I is the moment of inertia of the $\frac{1}{2}$ seconds balance,
R its radius of gyration,
W its weight, and also the weight of the others,

the moment of inertia of the seconds' balance must

$$= 2\ \mathrm{I} = 2\ \mathrm{R}^2\ \mathrm{W}.$$

Then if we call $\mathrm{R}_1 =$ the radius of gyration of the whole seconds' balance, R_2 that of a balance of the same weight to vibrate two seconds, R_3 that of one to vibrate three seconds, and so on, we should have

$$\mathrm{R}_1^2\ \mathrm{W} = 2\ \mathrm{I} = 2\ \mathrm{R}^2\ \mathrm{W}$$

$$\text{and } \mathrm{R}_1 = \sqrt{\frac{2\ \mathrm{R}^2\ \mathrm{W}}{\mathrm{W}}} = \sqrt{2\ \mathrm{R}^2} = 1{\cdot}414 \text{ inches,}$$

because $\mathrm{R} = 1$.

$$\text{Again } \mathrm{R}_2 = \sqrt{\frac{4\ \mathrm{R}^2\ \mathrm{W}}{\mathrm{W}}} = \sqrt{4\ \mathrm{R}^2} = 2 \text{ inches,}$$

$$\text{and } \mathrm{R}_3 = \sqrt{6\ \mathrm{R}^2} = \sqrt{6} = 2{\cdot}45 \text{ inches,}$$

and so on.

Of course this is a very different thing from the case of the pendulum. In that case the *radius of oscillation* of the pendulum varies as the square of the time of vibration.

I should like very much to explain to you clearly the reason why the moment of inertia is the measure of the resistance of a revolving body, but I must postpone that pleasure until I have more leisure for the purpose; because a short explanation would involve necessarily the use of the integral calculus, which perhaps you are not familiar with; and an explanation which required only simple algebra and geometry would be a long one. You would then perceive that centrifugal force is not in question at all.

With regard to the other matters alluded to in your letter of the 25th ult., I agree with you that there are causes at work affecting the errors of chronometers, other than the theoretical one discussed in my first letter. Two chronometers, having apparently the same balance, escapement, spring, and motive power, may yet show different amounts of error under the same circumstances; but do not you think that those differences which you observe in such cases are owing to small imperfections in different parts of the mechanism, particularly in the balance-spring—imperfect isochronism for instance—such imperfections being so small that they elude the eye of the best artist? Very minute differences in the proportions of the fixed parts of two balances intended to be duplicates of each other will affect the moment of inertia in different temperatures, so that the variation in that quantity will be different in the two balances for the same variation of temperature.

I have examined your diagram of the motions of the rim of a balance, and no doubt it quite correctly shows what, in fact, I mentioned in my first letter, namely, that the motion of the compensation weights is not in the direction of the radius exactly.

It also shows clearly that the motion is less and less the further it extends from the centre, and that it is greater and greater as it approaches the centre. And this variation again would differ according as the weight was put nearer or farther from the cut in the rim. If the extent of motion caused by change of temperature was considerable, then the effects shown in your diagram would tend to partially counteract the secondary error; but as the extent of motion is in reality extremely small, it is doubtful whether those effects have room to make themselves felt.

I have been led on by the interesting nature of the subject to make this letter a tediously long one; but I hope you will excuse that, and not read more than you like of it.

Yours, very truly,
C. REILLY.

SIR,—I observe that some of the correspondents of the *Horological Journal*, who are debating the middle temperature error of the chronometer, are perplexed to know what law of motion it is which the inertia of the balance obeys; and whether, in order to compensate for the variation in the force of the balance-spring, the weights of the balance ought to approach the centre in an arithmetical or a geometrical ratio. I will not presume to offer an opinion of my own on this question, but I would rather refer any one who is interested in the matter to Mr. Denison's "Rudimentary Treatise on Clock and Watch Making," published by Weale, in 1850, and there they will find that the question is clearly stated and determined. At page 160, Mr. Denison, writing on the compensation of the balance, says: "*It is true of a balance as of a pendulum, that if it were composed of rods or spokes without weight, and a rim consisting of a single heavy line, or even a line with weight in only one point, the time of its revolution would depend (the force being the same) solely on the square of the radius of the rim.*" And again, at page 163 of the same treatise, Mr. Denison says: "*The inertia of the balance depends on the* square *of the distance of the weights from the centre.*" This is as plain and explicit as anything can be, and is quite conclusive of the matter. I have not seen any subsequent edition of Mr. Denison's work, but that which was true in the year 1850 is true now in the year 1875, and I therefore submit that chronometer makers cannot do better than base their calculations, and their reasoning, and their practice upon what Sir E. Beckett has said in these quotations, and if they persevere, no doubt the obstinate middle temperature error must ultimately yield to their efforts; that is to say, of course, if they should live long enough.

HENRY PHILLIPS PALMER.
Leominster.

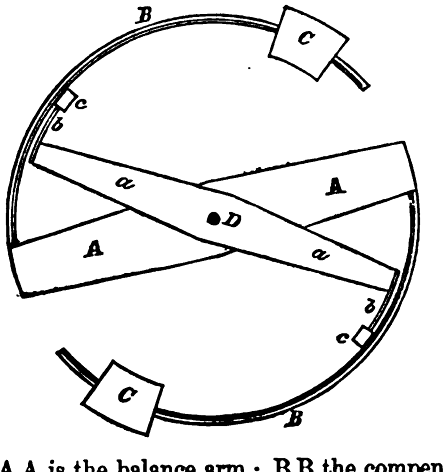
COMPENSATION ADJUSTMENT BY THE ASTRONOMER ROYAL.

SIR,—It has for many years been the practice at the Royal Observatory to test for compensation all Royal Navy chronometers after repair, and all chronometers sent to the Observatory for trial, and long experience in

rating these chronometers, has shown that whilst freedom from irregularities depending on mechanical causes is most remarkable, there is frequently defect in the thermal adjustment. The ordinary balance can be made accurate only within certain limits, because of the secondary error which so many makers have, by auxiliaries of various kinds, endeavoured to correct; but the limit of attainable accuracy in the ordinary balance is often not reached because of the difficulty of making with certainty the small final adjustment in the positions of the compensating weights, whilst there is the additional disadvantage of possible disturbance of the equilibrium of the balance.

The considerations mentioned having long been felt by the Astronomer Royal, he has recently proposed a plan for more easily and certainly making the final compensation adjustment, which, having received the approval of some able chronometer makers, may be of interest to many readers of your journal.

The construction is shown in the annexed diagram, in which is figured as much of the balance as is necessary to a clear understanding of the new attachment.



A A is the balance arm; B B the compensated rims carrying the ordinary compensation weights C C; D is the balance axis or staff. The new attachment consists of *a a*, an arm which can be turned with stiff friction on the staff; *b b* steel springs attached to *a*, just strong enough to keep the small weights *c c* always in contact with B. The weights *c* might probably be one-tenth of the weights C, or even less.

To adjust the compensation, the weights *c* should be placed somewhere near the middle position between the arm A and the weight C, and the compensation made as nearly accurate as may be by the weights C. Then if the compensation is found to be insufficient, turn the arm *a* so as to move *c* nearer to C; if the compensation has been overdone, turn *a* so as to move *c* from C. No other adjustment will be disturbed.

The plan will probably be found inexpensive, easy of application, and easy to manage, and could probably also be readily attached to many existing chronometers.

I am, Sir,
Your obedient Servant,
WILLIAM ELLIS.

Royal Observatory, Greenwich.
June 7th, 1875.

THE "EVERLASTING DRUM" AGAIN.

Sir,—I have read with some interest and amusement the discussion that has been going on so long about the misconduct in their work of the well-known "Drum" family. It seems to me that that family is pretty nearly being played out, unless a general move is made among the watch trade to take them in hand with an inexpensive remedy.

"Plymouth" says, that "the pallets embrace one tooth." Yes, and the remainder. I have three of these drums, one of which—a "dead"—embraces no fewer than eight teeth, another two, and the third only one. But here is a curious part of the business: the one tooth 'scape has the weakest spring, yet goes the longest and keeps the best time; the two-teeth one is next, and the "dead" is the most erratic of the three. The "dead" spring is very strong—in fact, I believe that the adjusting-rod would show that it must be nearly double the strength of the other two.

I am only an amateur; or, as my friends more aptly describe me, "a fellow who wastes half his time muddling his brains over clocks and watches." From this your readers will be better able—assuming that this letter is worth printing—to judge what value to attach to what I may say. Not being a practical horologist, and having no capital letters after my name, this caution may be all the more necessary.

Well, I bought three of these "drums" at different periods, just to see what could be got out of them, as much as anything else. Singularly enough, the "dead un" was "strongly recommended;" but, somehow or other, he has turned out the rankest "duffer" imaginable. I have treated him to the most refined tastes of "Young's celebrated," from the points of the most refined and "genteelest" of brooches, but still no good; furthermore, he has by far the largest swing, his depthing

is the clearest, and his pivoting the smoothest of all the three. I have tried his pendulum-bob as low as tenth turns on the screw-thread to get something like decency from him; but, instead of a minute or so for the day, he will very likely jump forward as many as five after we are all quietly in our beds.

My idea of this bad work of his is that the spring is too short for its power, and what I am thinking of as a remedy is to get a spring of, say, two-thirds the pull, and at least one-third more in length than the present one. From what little I have seen, I believe that the principal fault of all going-barrels made abroad lies in too short a spring for its strength. I have long entertained this opinion, and, in proof to me that there is something in it, I have been informed that the American Waltham Watch Company, recently established in London, use mainsprings in their watches of the proportions of three-and-a-half running lengths to the entire acting length of eight. That is, that taking a spring of eight complete turns, the movement only runs off three-and-a-half of those turns in the twenty-four hours. There seems to be sound mechanical sense in such an arrangement, as it is quite clear that the "pull" of the upper turns, with the whole power distributed over such an extended range, must produce very even time-keeping properties.

On account of the annoying behaviour and stopping of the "drums," there is a want of confidence arising about them among the drum-buying community; indeed, I have, on several occasions, when asked, advised my friends to have nothing to do with them, unless under a guarantee from a respectable trader.

I am greatly afraid that this letter is already much too long; but I cannot omit to mention a circumstance that I have not seen noticed hitherto: it is this. I live abutting on the line of the underground railway, having along the street-front of the house a main line of thoroughfare. Now, mark this: the traffic, in the railway-tunnel causes a certain amount of sensible vibration in the house; when, therefore, that traffic is unusually heavy, both the "drums" in the back rooms will stop during the night. Again, when both road and rail are "hard at it," the vibration is opposite and re-actionary, and the result is that, in the morning, not a single beat can be heard from any "drum" in the three! Of course we all know how that arises. The pendulums being so very short get the "twitters," and are soon settled. Another drawback with these "drums" is that they cannot be meddled with by a general member of the family, should the "expert" be out of the way, without putting them out of beat, and so killing them. With respect to the stopping in the last few turns of the spring, the simplest remedy that I know of is to wind them up twice a week, as I now do.

What is really wanted by thousands of people is a fairly reliable, strong, roughly-finished lever-escapement drum, good to about two or three minutes a week, that anybody can manage, and that will go anyhow or anywhere; that can be carried from sitting to bed-room, and *vice versa*. Who will seize the really *golden* opportunity?

The only way to obtain such a position as that of drum-maker to the British public is by the judicious combination of capital, machinery, and the concentration of manufacture under one roof. We have already, I know, going-barrel cylinder, and lever-drums; but they are too dear for the million, who buy the French ones. When the price turns thirty shillings, people begin to look twice at it. With a system established on the above-named principles, it might be kept down to that sum as the maximum for good but not gaudy work.— I am, yours, &c.,

AN AFFLICTED ONE.

WINDING-SQUARES.

SIR,—Mr. Whittaker having expressed an opinion (*Journal* of June, page 149) that winding-squares to keyless watches were unnecessary, would he oblige by stating how barrel and arbor should be taken from bar of a Geneva watch not provided with square?

I have frequently had trouble with such in taking to pieces to clean, in fitting mainsprings, and other repairs, and his advice would, I think, be of service to others beside a

COUNTRY JOBBER.

THE BREGUET-SPRING.

SIR,—I have read with much interest Mr. Glasgow's papers upon springing, and quite agree with him as to the value of the Breguet-spring.

Having been engaged for the last fifteen years here and in the house of the inventor in timing with these springs, and having provided several hundred watches with them during that time, I can speak with some experience of the excellent results to be obtained from them.

I think they are the best, as they are certainly the most natural in action, of any in use.

I do not quite agree with Mr. Glasgow in the necessity for their extra length, as I have obtained equally good results from the usual open coils; and if perfect isochronism can be obtained with the shorter spring, it is surely unnecessary to increase its length, thereby increasing the compensation error. The index is certainly both prejudicial and useless; it cramps the action of the spring, and therefore must interfere with its regular performance, besides never being required with a properly adjusted watch.

L. DONNE.

49, Cornhill.

RAILWAY INSURANCE CHARGES.

Mr. Allport, general manager of the Midland Railway, was a witness on Monday, 14th June, before the House of Commons Select Committee, which is inquiring into the working of the Carriers' Act. He suggested that as there would probably be no legislation on the subject this session, the companies should try, as an experiment, a universal rate of insurance for goods of 1s. per £100 upon the value of every class of merchandise carried by them. If the Government would consent to this arrangement, he would recommend that the system be commenced on the 1st August next, and be in operation for six months. The object of the companies was to protect themselves against heavy loss, and he would, for one, accept less than 1s. per £100 as insurance on the carriage of goods, if that would pay them for that loss.

MR. COLE'S TREATISE.

The following amounts have been received, or promised, since last month, in answer to the invitation of the Council to contribute to the fund required:—

	£	s.	d.
Mr. R. Gardner, Jun., Glasgow	0	5	0
Messrs. McGregor and Gardner, Glasgow	1	1	0
Mr. Mairet	1	1	0
Mr. A. Trevelyan, J.P. Tranents, N.B.	2	0	0
A Country Finisher	0	5	0

"On Making and Applying Balance-Springs."—In the article on this subject, in the June No. of the *Journal*, the sentence beginning at line 22, 2nd column, page 153, should read, "Therefore, I assert that a spring with ten turns is too short, and, in consequence, a watch with a spring of that length will *gain* in the short arcs and *lose* in the long arcs."

To Correspondents.

Will any reader kindly inform me h stop the scratching noise of a musical b have put pins and hair springs to sever could never stop it from scratching.

Apprenti

I have recently had in my hands a clock-watch, on the locking-plate pri bearing the name, "Jeremie Gregory, at Exchainge" (sic). I should be glad to at what time he lived, if you will kindl the question in your Correspondents' Col

W.

A Canadian Time-Ball.—A new vatory has been completed at Quebec connection with this institution a tim is dropped every day from the citad electricity, giving the ships in harbo opportunity to rate their chronon correctly. The only other time-ball i Dominion of Canada is at St. John, Brunswick.

In 1316, Prior Henry de Estria b five bells for Canterbury Cathedral, wl one, weighing 8,000 pounds, was called Thomas, and was placed in the great house. Three others were set up in a long clock-house built about that Somner, in his "Antiquities of Canterb 1640, makes no mention of so early a as that named above being at that city. is very elaborate and exact in his staten and therefore it is noticeable that if su clock had been erected there the fact es his attention. But he records that Wi Benet, who was Mayor of Canterbu 1450, and who had been various times one of the bailiffs of that city, by hi gave to the parson and wardens o Andrew's Church there 4s. 4d. per ann keep and maintain the clock for ever. incident shows that the public utility of began to be appreciated at that time. fate of the clock at St. Andrew's doe appear; but we find that several parishi of Canterbury bequeathed money at th of the fifteenth century for the making new steeple to that church, the wh which building was pulled down abo year 1764. The gift of a clock to a c was anciently deemed to be a most imp benefaction.

British Horological Institute.

he Annual General Meeting for the election of officers, and the transaction of ordinary ss, was held at the Institute, on Tuesday, 20th July, Mr. E. D. JOHNSON presiding.

reading the minutes of the previous l meeting, the Secretary read the re- id balance-sheet appended:—

ORT FOR THE HALF YEAR ENDED 30TH JUNE, 1875.

issuing their report for the period ting the seventeenth year of the In- 's existence, the Council congratulate embers upon the satisfactory position ch the Institute has attained, both in of the work it undertakes, and the by which it is supported. The mem- ve increased in number; the receipts les of the *Journal* are in excess of any half-year. With the continued assist- the Goldsmith's Company the classes een attended by a greater number of ts, with most satisfactory results.

announced in the *Journal*, the Council nade arrangements with Mr. James on Cole, whereby Mr. Cole is to write *Journal* a treatise on Isochronism, the results of his many years' ex- e. Of the £100 to be paid to Mr. r this work, the Baroness Burdett- with the readiness to assist in any promising useful scientific results ch she is conspicuous, has subscribed The remaining £50 the Council pro- raise by means of a subscription set on foot among the members and de generally.

ring the latter part of last year the l unexpectedly received from the Post uthorities an application for a rent of year to be paid in future for the wire which the time-signals are received nstitute from Greenwich Observatory. instance of the Council the President d a memorial, which was sent to ohn Manners, the Postmaster-General, forth the history of the concession, ying stress upon the fact that the District Telegraph, and other com- had erected and maintained the wire s without charge, on account of the ac- lged public importance of chronometer being furnished with exact time. The the memorial not being of a favoura- ure, the Postmaster-General, at the of the Council, conveyed through Mr. Torrens, M.P., received a deputation on the subject. As no further demand has been made since the interview with Lord John Manners, which was of a reassuring character, the Council hope to be able to report, on a future occasion, that no change has been made in the conditions by which the time-signals are furnished to the Institute.

"In their last report the Council had regretfully to record the death of Mr. Klaftenberger, one of the vice-presidents. Mr. E. D. Johnson, another of the vice-presidents, has lately intimated, through the Council, his desire to resign that office on account of failing health. The duty, therefore, devolves upon the members, at the present annual meeting, of electing two vice-presidents to fill the vacancies thus occasioned. The Council cannot forbear adverting to the indebtedness of the members to Mr. Johnson for his zealous labour at the initiation of the Institute, and for his ready aid at the critical periods which have so often occurred in its fluctuating history. His help and presence will not be entirely lost, as he expresses his willingness to accept a seat at the Council.

"The last of some interesting discussion meetings on the compensation balance which took place in January, a Paper on a Keyless Going-barrel Mechanism, read by Mr. Whittaker in May, have been fully reported in the *Journal*. The experiment made last year of arranging for members of the Institute to visit institutions and works of interest gave so much satisfaction as to induce the Council to obtain permission for a series of visits during the present summer. The first was made in June, when about forty members had the privilege of inspecting the magneto-electric clocks of Sir Charles Wheatstone, and other objects of interest at the British Telegraph Manufactory, in the Euston Road. The Council desire to acknowledge the kindness and courtesy of Mr. Robert Sabine on that occasion. Members will notice particulars of future visits in the *Journal*.

"The Council have to acknowledge the following additions to the museum and library:—

"Greenwich Observations for 1872, and

the Report of the Astronomer-Royal to the Board of Visitors, 1875. Presented by the Astronomer-Royal.

"The Cape Catalogue of 1159 Stars. By E. J. Stone, M.A., Her Majesty's Astronomer at the Cape. Presented through the Astronomer-Royal.

"An Antique Watch. Presented by Mr. R. E. Chambers.

"A Portrait of John Arnold. Bequeathed by Mr. Ulrich.

"Seventeen members have been elected.

"By Order of the Council,

"F. J. BRITTEN,

"*Secretary.*"

Balance Sheet for the Half-year ended June 30, 1875.

INCOME.

	£	s.	d.
To Balance in Treasurer's hands at last Audit	10	11	9
„ Balance in Treasurer's hands (Building Fund) ...	53	17	0
„ Donation (Goldsmiths' Company)	50	0	0
„ Subscriptions	74	6	0
„ Sales of Journals	57	12	0
„ Advertisements	51	3	0
„ Drawing Class Fees ...	3	7	6
„ Sundries	0	5	0
„ Subscriptions received for Mr. Cole's Essay ...	9	1	6
„ Six Months' Interest of Building Fund ...	1	6	11
	£311	10	8

EXPENDITURE.

	£	s.	d.
By Rent and Taxes	38	1	10
„ Salaries, Wages, and Commissions...	57	12	7
„ Journal Expenses ...	91	5	2
„ Stationery, Stamps, &c. ...	7	8	0
„ Printing and Advertising...	1	19	3
„ House Expenses	3	15	11
„ Gratuity to Mr. J. G. Ulrich	5	0	0
„ Sundries	3	1	2
Balance			
By Cash in Treasurer's hands...	48	2	10
By Cash in Treasurer's hands (Building Fund) ...	55	3	11
	£311	10	8

The CHAIRMAN, in moving the adoption of the report and balance-sheet, said the report was the most favourable in the annals of the Institute. In its early days they had never doubted that the Institute was capable of expansion, and their exertions had been rewarded by success. It was founded in trouble. They had to encounter the fierce opposition of those who were blind to their own real interest. They received the project as they would have welcomed iced water in cold weather. Well, they had happily lived through an age of hostility, and arrived at an age of prosperity.

One paragraph in the report was particularly gratifying. He believed the Council by their prudent conduct had rescued the Greenwich grant of a time-wire from jeopardy. No little tact, he was sure, was required in a matter of that kind, to steer clear of difficulties. With regard to the arrangement made with Mr. Cole, it certainly came very quickly after the prize essays on the same subject. He hoped the result would justify the handsome sum proposed to be paid to Mr. Cole for his experience. At a later period he should have a few words to say in reference to the paragraph which spoke of his retirement. He would now move the adoption of the report and balance-sheet; they were, he could testify, both substantially and minutely accurate.

Mr. JACKSON had much pleasure in endorsing the observations of the Chairman as to the prosperous condition of the Institute. As treasurer he could vouch for the accuracy of the figures. Even though it were a repetition of what they had already heard, he could not help expressing his gratification that such progress had been made as was shown by the report and balance-sheet. It was by far the best balance-sheet that had been submitted, or at all events, since he had held his present office. Speaking officially for the last time, he wished to say that the duties of treasurer, which had certainly been onerous in former years, were comparatively light owing to the admirable system of accounts now adopted. One point he thought deserving of the individual attention of the Council was, the desirability of introducing new members. He knew it was sometimes disagreeable and invidious to press the claims of the Institute, but in many places it was still unknown.

gged leave to second the adoption of port and balance-sheet.

Bickley said, the number of members e weak point in the report. In the aragraph they were told that the mem- 'ere increasing in numbers, and at the ey found that seventeen new members een elected in six months. They were ld how many had resigned or died in ime. The *Journal* no doubt was suc- l; it yielded in sales and advertisements than the members' subscriptions; but nstitute was never designed to be a hing office alone. More efforts, he ht, should be made to disseminate al knowledge; technical articles n by skilful men in the different es would be very acceptable. If an ment maker, for instance, gave them a nvarnished account of his method of ure, it would give young men an oppor- of becoming better workmen in a trade one branch dovetailed into another, as hmaking. He thought some one should ited from the Goldsmiths' Company to t the work done in the classes. He had an opportunity of seeing the drawing at work, and was much gratified to he attendance so large. The mem- uld judge of the quality of the work drawings exhibited. He trusted an t appeal for co-operation would be o those who had the interest of the t heart.

report and balance-sheet having been nously adopted, the Chairman read lowing list of officers nominated, and d the whole to be duly elected:— ent—Sir Edmund Beckett, Bart., , Q.C., F.R.A.S.; Vice-Presidents— Jones, F.R.G.S., Samuel Jackson, Glasgow; Treasurer—Thomas '; Council—C. Bacon, 37, Gerrard Islington; G. Barter, 41, Wilmington , W.C.; H. Bickley, 33, Half Moon t, Barnsbury; W. B. Crisp, 174, St. Street Road; J. Evans, 89, Mount Grosvenor Square; G. W. Frodsham, nge Alley, E.C.; G. Hollister, 37, Street, Berkeley Square; G. Hooper, er Chadwell Street, E.C.; M. Immisch, egent Street, W.; H. P. Isaac, 147, ol Road, N.; E. D. Johnson, F.R.A.S., mington Square, W.C.; C. Killick, ackington Street; V. Kullberg, 105, ol Road; C. Lange, 99, Strand; J. d, Cornhill; G. Mayer, 33, Charlotte New Road, E.; G. Morton, 31, er Street, N.; T. Nelson, 31, Halton Canonbury; J. Penn, 31, Queen's Road, Peckham, S.E.; E. Perrett, 23, Abingdon Street, S.W.; G. Prickett, 5, Corporation Row, E.C.; W. H. Prosser, 88, Bartholomew Road, N.W.; W. G. Schoof, 99, St. John Street Road, E.C.; A. Smythson, 1a, Harpur Street, Red Lion Square, W.C.; R. Strachan, F.M.S., 11, Offord Road, Barnsbury; A. Thickbroom, 6, Spencer Street, E.C.; A. P. Walsh, 5, George Street, Euston Road, N.W.; T. J. Willis, 10, Rydon Crescent, E.C.

The Chairman, then proposed a vote of thanks to the President, which was seconded by Mr. Jackson, and carried unanimously.

Mr. Jackson said, he desired to propose a vote of thanks to the Vice-Presidents. Such a vote had a special significance at that time, because Mr. Johnson, to whom they owed so much, from whom they had had such long service, was about to retire into the ranks. No words of his were necessary to bring to their remembrance the ability and constant labour for which they were indebted to Mr. Jones. He moved that the warm thanks of the members be tendered to the Vice-Presidents.

Mr. Glasgow felt it would be impossible to overrate the services of Mr. Jones, in whose absence he could speak of the thoroughly unselfish devotion, the enthusiastic and sanguine spirit which he ever manifested. Without Mr. Jones he believed the Institute would many times have found its difficulties insurmountable. He seconded Mr. Jackson's motion with much pleasure.

The Chairman, in acknowledging the vote of thanks, which was carried enthusiastically, said he would not seek to conceal the exertions he had made in the early days of the Institute. It had been said that the approbation of the master is the sweetener of labour, and he had not gone unrewarded. He could declare that what he had done was for love of the trade; aggrandizement or gain was never in his thoughts. But a man attempting to do good would find he had not a bed of roses. If he succeeded he would be hated for his success. A terrible cynic had averred that "we love only those upon whom we have bestowed good; those we injure we hate." The Institute had developed—it was a success. He felt proud to receive such evidence of their approbation for what he had done. He should take leave of them, feeling sure that others would do the like and better the example.

Mr. Bickley proposed a vote of thanks to Mr. Jackson, who had held the office of treasurer for eleven years, and through times of financial trouble sufficient to deter most men.

The vote of thanks having been seconded by Mr. Perrett, was put to the meeting, and declared to be carried unanimously, by the Chairman, who could not refrain from bearing testimony to the long service and zeal of Mr. Jackson.

Mr. Jackson, in reply, expressed the pleasure he felt in doing what he could for the Institute. He was sure neither he nor his coadjutor (Mr. Glasgow) coveted the honour which the members had thought fit to bestow upon them.

Mr. James Pyott and Mr. C. H. Hawkins were re-elected auditors, with thanks for past services, on the motion of Mr. James U. Poole, seconded by Mr. Martin.

A vote of thanks was then accorded to the secretary, on the motion of Mr. Glasgow, who took occasion to thank the members for the honour they had done him in electing him vice-president.

LIST OF NEW MEMBERS.

Brockman, John Henry, Adelaide, South Australia.

Cairns, —, 156, New Bond Street, W.

Chambers, —, 18, Powell Street, E.C.

Cuendet, A., Watch Manufacturer, Sainte Croix, Switzerland.

Denman, E. G., Watch Maker, 56, Napier Street, Hoxton.

Elliott, Jas., Clock Maker, 30, Citizen Road, Holloway, N.

Garnish, W. H., 6, Davies Street, Berkeley Square, W.

Gillett & Bland, Messrs., Whitehorse Row, Croydon.

Guye, Auguste, Watch Manufacturer, 13, Northampton Square

Lee, Jas. Bacon, 25, Northampton Square, E.C.

Mairet, —, Watch Maker, 4, Rydon Crescent, St. John Street Road, Clerkenwell, E.C.

Patton, James, Watch Maker, Newtownards, near Belfast.

Pickett, —, Clock Maker, Halfway Street, Bexley, Kent.

Ritchie, Federick James, Leith Street, Edinburgh.

Stuart, The Ven. Alexander, Archdeacon of Ross, 10, Rathmines Road, Dublin.

Walford, W. H., Watch Maker, Buckingham.

Wood, G., Watch Maker, Mortlake, Surrey.

VISIT TO MESSRS. GILLETT & BLAND'S CLOCK FACTORY.

The second of the summer visits took place on Tuesday, 27th July, when the members inspected the Steam Clock Factory at Croydon, at the invitation of Messrs. Gillett and Bland, and had the advantage of observing the various operations embodied in Clock Making. In the iron foundry, which was the first department visited, the moulders were engaged in impressing upon sand wooden patterns of frames for turret clocks, dials, weights, &c. Into a cupola adjoining, portions of pig iron were being thrown, and the fire therein impelled by a strong blast from a fan, actuated by an engine in another part of the works. In one corner of the foundry is a stove for drying cores and moulds, consisting of a brick arch, heated by means of a fire in a trench below the floor covered over with a grating. When small holes are to be left in castings a projection of similar section to the required hole is placed upon the wood patterns; in the indentation which this projection makes upon the sand is fixed what is called a core, which is sand rammed so hard into a box of the shape desired that it will turn out a solid mass; it is then baked in the stove to which we have referred. The object of applying this core instead of leaving the hole in the pattern, is to save time in moulding and to avoid the danger of being washed away by the molten iron when poured in, to which a projection of ordinary loose sand would be exposed. Barrels for turret clocks and other articles of cylindrical form are often made without a wooden pattern, the wet sand being formed to the shape intended, and dried in the oven in the same way as the cores. While we have been inspecting the oven, and learning these particulars, the moulders have removed their patterns from the sand and are getting ready to fill the mould with the liquid iron. A man in a leather apron now approaches and "taps" the cupola with a long rod, when the melted iron quickly runs in a thick stream down a gutter into a large basin or pot, daubed over the inside with fire-clay. When the pot is full the source of the stream of iron is dexterously stopped with a plug of fire-clay, and the moulders bear away the pot by means of a long cross handle, and pour the iron into the mould. During the process bright stars of fire continually start from the stream of iron, and a roaring and cracking noise is heard as the air and steam escape from the mould. The castings we have seen poured will remain in the sand to cool till the following day; but as we pass through

oundry we see men removing the sand excrescences from some cast previously. ljoining the iron foundry is the brass lry. In addition to the ordinary brass for clocks, Messrs. Gillett and Bland all their musical bells for chime clocks or clocks playing any number of tunes. clock just completed was arranged to play ity tunes, we are told, as we pass through. om the brass foundry we are conducted igh the smithy and the fitting shops, e machinery of various kinds for turret s, chimes, and carillons is turned, planed fitted to the exact size and form red. Messrs. Gillett & Bland have years devoted attention to the perfec- of chiming machinery. Formerly the in the musical barrel had to lift and arge the hammers, an arrangement ring very strong pins, while the time of music was spoiled by the interval occu- in overcoming the inertia of heavy ham- , in fact, delicacy was out of the ques- on account of the cumbersome and y machinery necessary. A plan was ver conceived of separating the two ns; allotting the duty of letting e hammers to the musical barrel, and ng a separate barrel, or series of cams, nually revolving to raise the hammers ey were discharged. This was evidently ight idea, but all who have had any- to do with reducing mechanical ideas ractice, will appreciate the care, and ght, and labour which must have been ided by Messrs. Gillett & Bland before first complicated device was brought, ccessive improvements, to the simple and nt arrangement they now use, a brief iption of which will suffice, although els embodying the different stages were n to the members. A horizontal rocking , which may be described as resembling le beam, has one extremity held in a to prevent it from rising. Between extremity and the axis is a shackle com- cating with a cord to the tail of the ner. At the proper moment the pins e musical barrel release the catch, and ammer falls upon the bell, pulling up end of the rocking lever, and, of course, essing the other end, from which a r hangs freely. Directly the hammer struck the bell, this finger engages a of a widely pitched wheel, always ving, and the rocking lever is instantly cted to its former position by the ed wheel, carrying the finger up until divergence of the path of the wheel s it to fall off.

Messrs. Gillett & Bland have also invented a plan of damping the bells, so as to avoid the horrid effect produced by one note running into another, so apparent in moderately quick music played upon bells in the ordinary way. Under ordinary circumstances, each bell has a leather damper pressing upon it, which is removed by the action of discharging the hammer. Another improvement introduced by them in connection with bell music is a band of leather which may be interposed at pleasure between the hammers and the bells, with a view of obtaining *piano* and *forte* effects. It will be understood that in chiming machines made as we have described —with the hammers lifted by the auxiliary barrel or cams—a keyboard may be substituted for the musical barrel, and any tune within the compass of the bells played by hand as with a piano or organ, and, indeed, Messrs. Gillett & Bland have not only applied keyboards to church carillon machines, but have introduced what they call a campanula, or bell piano, in which the dampers and other inventions spoken of are embodied.

The carillon machines that Messrs. Gillett and Bland have put up at Worcester Cathedral, Bradford and Rochdale Town Halls, St. Stephen's Church, Hampstead, and other places are made on their improved system; and the one recently put up at Shoreditch Church contains still further important improvements, which we shall probably describe in detail shortly; and at a church near Manchester a keyboard has been attached to the carillon machine, playing fourteen tunes on thirteen bells; so that one accustomed to the piano can play tunes upon the bells with the fingers.

We have devoted so much time to mechanism connected with bells, because it occupies a prominent position in Messrs. Gillett & Bland's factory; but there is ample evidence around that no appliance is wanting for making large clocks cheap and well. The cast iron wheels are trimmed in a self-acting machine by means of rapidly revolving discs of emery. A disc being selected of a section corresponding to which should be the space between two teeth of the wheel to be operated upon, the wheel previously fixed to the machine is brought into contact therewith, the machine started, and only stopped when the wheel is finished; when one space is dressed the wheel is lowered out of the way of the revolving disc and turns on its axis just sufficient to bring the next space into position. By using this machine the teeth of the cast iron wheels are brought to correct form at little cost. In course of manufacture we see

about a score of turret clocks, large and small, for churches and public buildings in all parts of the world, and preparations for making a clock and carillons for the new Manchester Town Hall, which will be the largest thing of the kind in the United Kingdom. The clock is to strike the hours upon a bell of seven tons, and to chime the four quarters on eight bells, the time to be shown upon four 16-ft. illuminated dials. An automatic gas apparatus will be fitted to the clock for turning the gas up and down, and so constructed as to suit all seasons of the year. The clock will also have an electric connection with the Royal Observatory at Greenwich. The carillon machine, on Gillett & Bland's improved patented system, is to play 31 tunes (a fresh tune for every day in the month) on 17 bells, weighing altogether about 30 tons, and will also have barrels for changes similar to ringing a peal, and an ivory key-board; and 12 of the bells are to be hung for ringing with ropes, being the first time that a ringing peal has been put up in any town hall. The seven-ton hour-bell will be the largest struck upon by a clock in this country excepting Westminster, and about two tons heavier than the one at St. Paul's. We hope to have some further particulars from Messrs. Gillett and Bland when it is farther advanced.

In all their turret clocks Messrs. Gillett and Bland use Denison's double three-legged gravity escapement, unless otherwise directed, but for regulators, &c., adhere to the dead-beat as giving equal performance and being less costly.

Although not in the order of the visit, we may as well mention here that the turret clocks, of whatever size, when finished, are hoisted into an upper shop, painted and set going, and, after sufficient trial, lowered whole into a packing-case.

After the excellent arrangements in the shop devoted to the larger kind, we were rather disappointed with the means for producing small clocks. We rather expected, from the evident ingenuity and mechanical skill shown as far as we had gone, some particular duplicating machinery, for which there certainly seems room. We must not, however, forget the chronograph, as Messrs. Gillett & Bland term a somewhat clever production, in which the ordinary dial and hands are dispensed with, and the centre of what would be the dial is a rectangular slit, through which are seen figures denoting the hour and minute, a small hand and dial to one side recording the remaining seconds. At the sixtieth second and the sixtieth minute the figures are quickly changed, the drums upon which they are painted being made wholly of vulcanite, and very light, offering but little inertia to be overcome. Good chime and quarter clocks, for which England still holds her own, receive considerable attention here. One shop appeared to be devoted to the making of clock cases of every description and to suit all climates; another shop is set apart for the making of patterns, where the two-foot rules of the men measure two feet and a quarter of an inch, to allow for the contraction of the iron in cooling.

There were several departments through which the members were shown, of which we have not space to speak.

We have to thank Messrs. Gillett & Bland for their courteous explanations, and for a sight of what is certainly the most complete clock factory in England. Altogether, about 60 men are employed, some of whom are constantly away fixing clocks and carillons.

Assay by Means of the Spectroscope.

In my last Report, says the Deputy-Master of the Mint, I stated that experiments were in progress to determine whether it would be possible to adopt a proposal made by Mr. J. Norman Lockyer, F.R.S., to use the spectroscope in the quantitative estimation of the precious metal in alloys used for coinage. The results of these experiments were communicated to the Royal Society, and will shortly be published in the Philosophical Transactions. They confirmed the opinion which I expressed last year that by the aid of the spectroscope differences of composition more minute than the one-thousandth part might be readily distinguished, but we were convinced that, in order to establish a process which would enable us to displace the existing methods of assay, it was necessary to procure more delicate and powerful instruments than those which had been employed in the laboratory experiments, and to assimilate the conditions to those which would occur in practice. The necessary apparatus has now been procured. I may mention that Mr. E. Rigg, who has recently been appointed Assistant Assayer, has already proved himself to be a skilful and patient experimenter, and that his assistance in prosecuting the enquiry will be of much value.

ELECTRO-SYMPATHETIC CLOCKS AND TIME-SIGNALS.

A Paper Read before the Royal Scottish Society of Arts, April 28th, 1873.

("REID AND AULD" PRIZE.)

BY

FREDERICK JAMES RITCHIE, ESQ., F.R.S.S.A.*
MEMB. BRIT. HOR. INST.

THE application of electricity to time-keepers and time-keeping dates from the early experiment in telegraphing signals and letters by the aid of voltaic electricity, and has engaged the attention of several scientific men during the past thirty years, resulting in many ingenious contrivances, but all proving more or less unsatisfactory and uncertain, either from the unsteady performance of the clocks as time-keepers, or from the expensive and powerful batteries requisite to sustain the electric action.

It is not my intention here to enter into a detailed history of the several steps of the application of electricity as a motive power to indicate time, but shall briefly notice a few of those more prominent and successful results which have passed more immediately under my notice.

Electric clocks, or what have hitherto been so named, may be classified under three divisions :—

1st. Those whose motive power is wholly electric, and which are independent of any other force whatever.

2nd. Those depending on currents of electricity transmitted at regular intervals and applied directly to carry forward the wheel-work and hands.

These two classes require no periodical winding up, and may properly be styled electric clocks.

3rd. Those which being complete clocks in themselves, and capable of performing all the duties of clocks without the external aid of electricity, showing their own time and requiring winding up at certain intervals, but, for the purpose of being made more useful and correct time-keepers, have currents of electricity transmitted from some standard clock, so applied as to control and correct the vibrations of the pendulum or the movements of the wheel-work and hands, and so cause them to show uniformity of time with the governing clock.

About the year 1840, Mr. Alex. Bain, a native of the north of Scotland, and well known in our city, where for several years he carried on the manufacture of electric clocks, while engaged in experiments with telegraphic inventions, constructed an electro-magnetic pendulum, which we consider not merely the first but by far the greatest step towards a perfect machine, combining as it does power and simplicity, obtaining the most certain results with the smallest cost and expenditure of force and material, and, as a direct consequence, the smallest chance of derangement. Professor Oersted, of Copenhagen, discovered, in 1820, that when a current of electricity was passed through a wire, a magnetic action was induced which affected the needle of a compass placed near it, and that the influence was increased by passing the wire several times round the free magnetised needle of the compass. The effect upon the needle was reversed by changing the direction of the current.

Mr. Bain took advantage of this discovery and constructed his pendulum P (Fig. 1) by using a helix of wire R, each turn being insulated from the preceding, for the ball or bob, the wire ending in two insulated springs on which the pendulum is suspended. Fixed to the casing of the clock, and with perfect freedom to allow the vibrations of the pendulum over them, he suspended two bundles of strong permanent magnets or bars of hardened steel rendered magnetic, with a fixed N. and S. pole, having their similar poles placed in one direction, and slightly separated in the centre.

While the wire helix is in its normal state, the pendulum remains stationary ; but immediately a current is passed through the wire, an attractive force is excited in the coil towards the magnetic bar, and the pendulum being free to move is drawn in the direction of the pole of the magnet. When the current is cut off, gravity restores

* *Communicated, and, where necessary, adapted to the "Horological Journal," with the Author's permission by his friend, J. J. Hall, Esq., F.M.S.*

the pendulum to, and its inertia carries it beyond its point of rest. Mr. Bain made this very simple and effective pendulum to be self-acting by providing a sliding-bar moved by the vibration of the pendulum itself, which thus became an automatic make and break, and sustained motion so long as the battery continued in sufficient strength. The vibrations of the pendulum thus maintained he employed to carry forward the wheel-work and hands by a ratchet wheel and catch, having a friction roller and spring to keep the train steady.

Mr. Bain fitted up a considerable number of these clocks, and kept them in motion by a very weak battery, using merely a plate of zinc and copper, or carbon sunk in the moist earth, and really remarkable results were obtained; in some instances performing for some years without attention.

However, as time-keepers, they were subject to great irregularities, owing principally to the friction of the sliding bar affecting the free motion of the pendulum, and also to the irregular strength of the electro motive force, and have consequently fallen into disuse except as matters of scientific interest.

Many other attempts have been made to obtain more correct time-keeping by the direct aid of electricity. Amongst them was one, which promised much, by Mr. Shepherd, of London, whose electric clock was erected in a prominent position in the Exhibition of 1851. In it he adopted an ordinary pendulum propelled by a slight spring, which was wound up at the alternate vibrations of the pendulum by an electro-magnet; the wheel-work and hands were propelled by a separate electro-magnet excited at the same time by the same current. This system, however, although it proved more steady in time-keeping qualities than Mr. Bain's, required exceedingly powerful batteries, resulting in uncertainty in their action, and great trouble in attention. Such, to a greater or less extent, has been the experience of the first division of purely electric time-keeping clocks.

The second class, or those depending on currents of electricity transmitted by a normal clock, may more properly be called electric companions or dials, and all, or nearly all, consisted merely of wheel-work and hands, which were carried forward by electro-magnets excited by currents transmitted by the normal or time-keeping clock, which might be purely electric, or, better still, a clock on the ordinary principle. The idea of such copying clocks or dials originated probably with Sir Charles Wheatstone, whose great achievements in electro-telegraphy have lately become so valuable, and their construction has been carried on in various principles, both in this country, and on the Continent. Indeed, in some of the principal continental cities they have been adopted to a large extent. In Paris and Lyons, for instance, several are fitted up in lamps on the principal thoroughfares and in the chief hotels. To economise battery power in working them, one current is transmitted through a certain number for two or three seconds each minute, and move forward the hands one minute at a time. These, from their nature, however, require very powerful batteries to excite the electro-magnets which move forward the wheel-work and hands; and as a strong battery is much more liable to derangement, and even to suspension of force, for a time, occasional slips and trips occurred which destroyed the coincidence of time shown, and consequently errors arose. As an instance of this, I may state that the Electric Company erected a clock in the window of their office in the Strand, and spared neither trouble nor expense in endeavouring to drive it in this manner by the meantime clock in the Greenwich Observatory, with which it was connected by a wire, until its egregious blunders forced them eventually to close it up from view.

Not only has voltaic electricity been tried in this way, but magneto-electricity has also been employed with at least equal if not much more likelihood of success. About eight years ago I took out a patent for thus transmitting time through any number of clocks, but, unfortunately, from want of time, was unable to carry the matter into practice, and consequently allowed the patent right to drop, and there it lies—not forgotten, but I think as full of promise as ever, and as capable of supplying time to the hands of any number of clock-dials as any principle of electric companions yet introduced. The electricity in this case is not produced from a voltaic battery, but is derived from a powerful magnet, having coils of insulated wire on each pole. When the magnetic circuit is closed, a current of momentary duration is induced on the wire coils; and when the *armature* is removed and the circuit opened, a current is induced in the reverse direction. On this principle, and by using compound magnets, currents of most intense power are produced, as, for instance, in the magneto-electric telegraph, such as Wheatstone's ABC, which is constructed to produce movements of the needle at 800 miles distance, and in the powerful magneto-electric exploder of Wheatstone's, which I shall afterwards notice; and also in the production of the electric light,

which surpasses all others in brilliancy, and has been introduced in some of our lighthouses, where the illuminating power requires to be of very high character. The mere mechanical part of causing the armature to rotate in front of the magnet poles might be performed by a weight or other motive power, and might be continuous, or started at regular intervals, by a governing clock. When in London last spring, I was not a little astonished to see my ideas of that time patented and carried out in a telegraph manufactory, and actually the very means made use of to open and close the magnetic circuit which I tried then and cast aside as being fatal to time-keeping in the normal clock, whose pendulum, in its vibration over the magnets, acted as the make and break. The irregularities of the one in London were admitted to be very great, and special provision was made for its correction at short intervals by connection with an independent clock.

I urged the adoption of Mr. Jones' system of controlling to the pendulum, but have not heard whether it has been added.

I made use of a very light escapement, worked by a very fine electro-magnet, to carry forward the hands with a decided beat, while the London patentee adopted a revolving magnetised needle inside a wire coil,

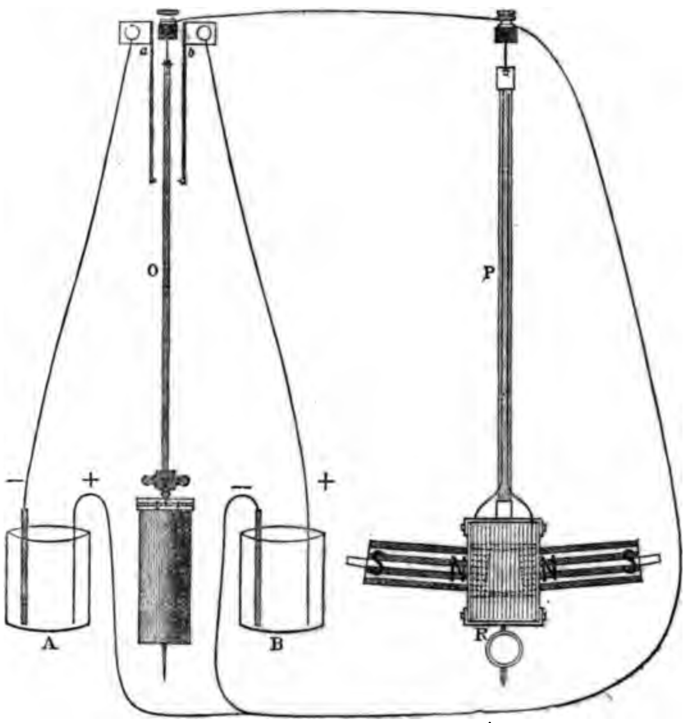


Fig. 1.

similar to a galvanometer, which moved forward the hands with a uniform and continuous motion.

This brings us now to the third division, or those clocks which are in themselves complete, requiring periodical winding, but merely corrected in their time-keeping by currents transmitted at certain intervals from some standard clock.

In 1840 Mr. Bain suggested a plan whereby the errors in time of an ordinary clock might be removed every hour, by means of an electro-magnet acting by a V-shaped piece on the minute hand. Mr. Walker, of the Electric Telegraph Company, also adopted a plan which was carried out in several of the telegraph offices in the principal towns. The clocks were regulated to gain a few seconds daily, and about thirty seconds before ten A.M. each day, an arm was allowed to drop and catch on a pin in the seconds wheel, thereby stopping its progress until the current transmitted at ten o'clock from Greenwich withdrew the arm by exciting an electro-magnet, and allowed the wheel-work to go on as before. By this means the clocks were set daily to within two seconds of true time. These, however, are merely approximate refinements in time-keeping, and also required powerful batteries to produce the result.

About sixteen years ago Mr. Jones, then manager of the railway station at Chester, had his attention called to electric clocks, and attempted by means of large electro-magnets to drive the wheel-work and hands of a large dial within that station. After spending much time, labour, and expense, and covering the floor of a room with batteries in alarmingly increasing numbers, the happy thought occurred to him, that as Mr. Bain had succeeded in driving not only his pendulum, but also his clock, with the small power obtained from a copper and zinc plate sunk in the earth, surely Mr. Bain's pendulum, if applied to and driven by an ordinary clock, could be caused to vibrate in unison with that of an astronomical clock, if such was employed to transmit currents to it at regular intervals.

The success of the experiment was soon placed beyond doubt, and the large clock, which no battery power was found sufficient to drive, was kept in check and caused to beat in coincidence with the normal clock. Afterwards, an old and cumbrous clock in the Victoria Tower in Liverpool, having six dials of large size, was kept beating time to a second with that in the Observatory there, with a very small expenditure of battery power. A small clock also at the Magnetic Telegraph Company's office on the Exchange Flags, connected with the Observatory, became the recognised standard of time. During eleven hours in one day, no fewer than 1860 persons were observed to compare their watches with it.

From extensive alterations and improvements at the docks, these clocks have been removed, and a new observatory erected on Bidston Hill, about three miles down on the Cheshire side of the Mersey, and the opportunity of controlling clocks in Liverpool has meanwhile been lost. We have the opportunity, however, of referring to those clocks in our own city which have proved so reliable —that in the Castle, which has fired the daily gun signal for the past twelve years, exposed as it is to every storm, and the vibration of the gun, which is within five feet of the clock case; and also those in the General Post Office, and that in front of the General Register House; all of which are provided with the means of reporting their accuracy, and do so every minute, day and night, to the Royal Observatory, where their performance is rigorously observed and recorded.

A few words will explain the controlling system.

(To be continued.)

Letters to the Editor.

All Letters to be addressed to the Editor, at the Institute, 35, Northampton Square, E.C.

NOTES AND REFLECTIONS ON MR. WHITTAKER'S PAPER IN THE JUNE NUMBER.

Sir,—I read with much interest Mr. Whittaker's paper on his stem-winding system, in the June number of the *Journal*, and trust that I have derived some knowledge from the study of his beautiful diagrams. There was one thing that I was especially glad to see; that was, that the grand old "line of centres" had at last been "taken on" in the new keyless work. He had a long time in the 'scapement business, and I was in great hopes, some years ago, of his being sent to take a pull between the fusee and barrel. However, he was shunted for some reason or another, and those hopes have been disappointed; therefore, let him, like a true believer, adopt the "eastern position," now so much contended for in other quarters, and pour out his gratitude accordingly. South-eastern will be nearer. But whether keylessism on the line of centres, or on the elbow, or any other of the hundred and one "lines," is the best, is not the purport of my present communication.

Having "a friend, who is in the trade," I have seen a goodly number of watches in my time, of all kinds and conditions; I have seen air-proof, and dust-proof, and *water-proof*. A friend, looking over my shoulder, cries, "Walker!" That is exactly it. It was "Walker." Did not I see, day by day, as supplementing Urban Jurgensen, in "The Higher Horological Art," watches going at the bottom of the crystal-*est* of tumblers, filled with the sparkling-*est* of water. As I gazed through the thickest of plate-glass, I exclaimed, "Shade of *Ut tensio sic vis!* Brave old Hooke!" (Mem.—This is the only horological Latin allowed to the masters of the craft.) *Tempora mutantur; Tempora labuntur; Tempori parentum; Tempus edax rerum*, and *Tempus fugit*, are only for the apprentices and outsiders like me. To be sure, *Tempus animæ est* is permitted to Cornhill, Cheapside, and the Strand, when wavering customers have a watch-covered counter in front of them, and want too much pap-feeding before they select and pay up. But, when all is said and done, *Ut tensio sic vis* is, beyond doubt, the ortho-

dox article. Still, as I looked at the waterproof "goods" on the inside of that window, I sighed, and exclaimed, "Shades of Hooke, of Huggens, of Harrison, of Graham, of Earnshaw, of Arnold, and all the great departed! that watch in water, that water in tumbler, that tumbler in window—that looks like business, that looks like getting on. This must be seen to." And now, Mr. Editor, we have come to pressure-proof and thief-proof. Let me have a think.

* * * * *

The value of "pressure-proof" I confess myself unable to appreciate, unless the balance cock is placed—like an ironclad's engines—below the line of shot; so long, I presume, as the balance is "exposed to the enemy's fire," by any liability to impact on either the upper jewel, or staff-pivot of the balance, so long will that side be vulnerable. Again, Mr. Whittaker has *not* said anything about the security of the dial side. Supposing the pivot of the minute hand and the hour hand end of the cannon pinion came in for a "ram," what is the security there? If it is only what we have at present, then I numskullically submit that all the back-door precautions are mere bolting with boiled carrots. My idea of a pressure-proof watch is that of an instrument completely boxed up in metal, "body and bones, edge and front, back and sides." What would be thought of a "pressure-proof" safe whose door was glass to enable you to see the contents? This simile runs exactly on all fours with a "pressure-proof" watch, so long as the wearer wants to look at the hands. With a minute repeater I admit that the thing might be done, for, in that case hands *may* be dispensed with. Let the inventive genius of Mr. Whittaker turn out something "hammer-proof" in that direction.

And now for the "thief-proof" part of the business.

I have looked carefully over the paper in the *Journal*, and, although I am somewhat acquainted with thieving, and thieving arrangements, I cannot find a single allusion to the "art" in what I have read. A "thief-proof" watch, I take it, without being too literal, is a watch that a thief cannot readily get away. There have been many contrivances of this kind from the bottom chain upwards—perhaps the revolving bow was as good as any. The best that I ever saw was one that I invented myself (!!!).

It did not "take" for two reasons: one was that it only cost a farthing, and could be got at any tailor's "trimming shop," and the other reason was because it was the surest "safety" that had ever been tried.

This was it:—A large farthing hook—of the hook-and-eye family—was strongly stitched under the upper seam of the watch pocket, and then hump-backed up a little. Upon this the watch was hung. On snatching it out with the chain the top of the pendant struck the hump of the hook, turning that guardian completely bottom upwards, with the open side against the breast of the waistcoat, the top of the bow pressing on the inside of the claw of the hook. The greater the pull, the tighter the locking, and, providing all things were strong enough, a man might be lifted off his feet by the chain of his watch in this way, but the —v—l a bit of the watch could be got out of the pocket. To take the watch out you had to press your thumb-nail against the upper part of the hook so as to prevent the pendant striking the hump, and the watch then came off.

Whilst that idea had "possession of my soul," I cost my friends a good deal in cigars and brandy in this way:—I risked my watch, and they risked their chains. I swivelled the chain on the watch, hooked the latter in the pocket, and gave "three snatches a shilling," I standing perfectly still. I never knew one of them win; in fact, I could never "unhook" myself without using the thumb-nail. I have seen as many as three guard-chains broken in one evening, but no watch taken. My wager was 2 to 1, but I never lost once. This is what I call "thief-proof" in earnest.

On the other hand, it was just as easy, after a day's trial, to take out your watch in this way as in any other. I was strongly urged to patent the "invention," but, as some of my friends would not take the trouble to have the hooks sewed on after I humped them for them, I did not see many signs of a harvest by patenting. Indeed, one lady cut a hook out of the waistcoat after it had been sewn in. Her husband was an engineer, and like most men of that scientific "persuasion," he carried a good-sized timekeeper—an 18, I think. When he went to bed, he was in the habit of hanging his waistcoat on his wife's bed-post, on account of the large dial and spade hands enabling her the better to see, by the winter morning's night-light, when to rouse up her handmaiden for the breakfastly coffee and eggs. She used to reach over and quietly draw out the watch by the chain, look at it, and as quietly slip it back again. One grisly morning, however, she gently drew up the chain, looking for the familiar face to rise

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END OF VOLUME XVII.

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